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# Recommending structured products as investment strategy

*Sales pitch or sound advice?*

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Master Thesis in Financial Economics

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This thesis was written as a part of the master program at NHH. Neither the institution, the adviser, nor the sensors are - through the approval of this thesis - responsible for neither the theories and methods used, nor results and conclusions drawn in this work.

# Executive Summary

This master thesis in financial economics asks whether banks have taken advantage of a superior informational position in the sale of so-called structured products. Structured products sold by Norwegian financial institutions have received extensive criticism over the last few years, and estimates show that customers may have lost more than 14 billion NOK by investing in these products.

The first part of this thesis will present the reader with a theoretical framework for understanding structured products, before providing an overview of the history of these products in the Norwegian context. The thesis will then use the Monte Carlo simulation technique to conduct a thorough analysis of the two products DnB Global and Sektor 2000/2006, which due to an impending litigation is expected to set presedence for how complaints on these types of products will be treated in the legal system. The analysis confirms the results from previous studies that these products had a negative expected return when debt financed.

In the second part of this paper I will conduct a more qualitative analysis, discussing issues such as why distributors were selling these products and why customers were unable to understand that the products represented inferior investment strategies. The thesis concludes that the banks have misused their customers' trust and confidence in the sale of structured products.

# Preface

Writing this master thesis was far more of a challenge than I initially expected, and it has as such been an incredible learning experience.

I want to take this opportunity to thank my supervisor Professor Alexander Cappelen for the valuable comments and constructive criticism he offered. I would also like to thank Stian Henriksen for technical assistance and finally James Quinn for extensive feedback and encouragement throughout the writing process.

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Line Grinden Quinn

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# 1. Introduction

*"Abraham Lincoln posed the question: 'How many legs does a dog have if you call a tail a leg?' Honest Abe's answer was four. A tail is still a tail even if you call it a leg."*

Kay (2009, p. 13)

## 1.1 Background

The quality of financial advice provided by banks and other financial intermediaries has been a hot topic in Norwegian media and academia over the last few years. Financial advisers have been highly criticised for their apparent failure to separate the roles of *adviser* and *seller*, and bank executives have been accused of chasing short-term profits instead of focusing on the long-term interest of their clients. Examples of poor financial advice are frequently coming to light, and the magnitude of these errors is a reason for concern. Some recent cases include

- Sparebank1's hedge fund sale to a demented 88-year old. The elderly gentleman was encouraged to place the vast majority of his liquid assets in the fund, which have lost 55 per cent of its value since November 2007 (Vanvik, 2009). The Norwegian Bureau for Banking and Financial Services Disputes (Bankklagenemnda) recommended that the bank compensate the man in order to restore him to his original financial position (Bankklagenemnda, 2009-005).
- In 2004 a 20 year old man with intermittent contract employment and no capital purchased a certificate of deposit linked to a hedge fund indexed. The seller was a financial agent for SEB Privatbanken, who also financed the NOK 500,000 investment, which was 2.4 times the 20 year-old's annual income (Gran, Hegle, & Mikalsen, 2009). Bankklagenemnda recommended that the bank should compensate the man so and return him to his original financial position as if the investment and loan-agreement never took place, as well as cover his legal expenses (Bankklagenemnda, 2009-019). The bank has pronounced that they do not intend to comply with Bankklagenemnda's advice.

In a recent opinion piece in Dagens Næringsliv[1], assistant professor Trond Døskeland (2009) of NHH comments that while private investors should exercise caution when taking advice from bank employees, they might not even be able to trust their own judgement in financial decision making. Recent international surveys have shown that many individuals are financially illiterate, that is, they do not understand the fundamental principles and relationships of personal finance (Organisation for Economic Co-operation and Development, 2005). Financial advisers thus face the challenge of not only providing the best advice possible, but also of ensuring that the clients truly understand how the proposed strategy can affect their wealth. Another challenge is that while advisers are expected to provide sound recommendations based on their clients' financial situation and risk preferences, they are essentially employees employed by the bank to sell the products that the bank is offering. This issue raises the question of whether it is possible to effectively and ethically balance the roles of *adviser* and *seller*. In essence this is a question of loyalty, and the frequent examples and criticism in the media suggest that the allegiance in many cases does not lie with the customers.

Many of the cases referred to earlier concern financial advice given in relation to the sale of so-called structured products. The perhaps most visible of these cases is the debate concerning the two indexed bonds DnB Global and DnB Sektor 2000/2006. Investor Ivar Petter Røeggen brought a complaint to Bankklagenemnda arguing that the bank failed to inform him that the *expected return* from debt-financing these two products were not only disproportionate to the inherent risks, but in fact *negative*. The complaint was based on conclusions from an extensive report prepared by Steen Koekebakker and Valeri Zakamouline at the University of Agder (previously Høgskolen i Agder). While processing the complaint was time-consuming Bankklagenemnda reached a decision earlier this year; they recommended that DnB NOR, Norway's largest financial institution, should restore the client to his original financial position, i.e. compensate him as if the investment never took place (Bankklagenemnda, 2009-001). The bank has chosen not to comply with this recommendation, and the complainant has commenced the process of pursuing the case trough the legal system (Forbrukerrådet, 2009b; Stranden, 2009). The case is of principal

[1] Norway's leading newspaper for business, trade and industry news.

importance as it is expected to set precedence for a number of complaints on the marketing, advice and sale on this particular group of products.

Structured products like DnB Global and Sektor became increasingly popular in Norway at the turn of the millennium, no doubt due to the fact that they seemingly offer a way to avoid the classic risk and return relationship of finance. These products were touted as a way to protect principal and snag market gains; a method of potentially achieving high returns all the while carrying low risk. *Then the credit crisis hit*. When the bubble burst it became evident that the quality of these products in many cases were just as bad as the army of academics warned; and they have as such become highly central to the debate concerning financial planning and advice in Norway. Bjerksund (2008) have estimated that Norwegian bank clients have lost in the vicinity of 980-1,276 million kroner yearly in fees, bank margins and hidden costs, before taking return on the actual investments into account[2]. The hard-earned lesson is, as financial markets have proven time and again; you can’t have your cake and eat it too.

## 1.2 Research aim and research questions

The main research aim of this master thesis is to analyse whether or not banks as product distributors and financial advisers have taken advantage of a superior informational position in the marketing and sale of debt financed structured products in Norway[3]. There are in particular two issues we need to address in order to provide an answer to the previous question. Firstly we need to show that these products are in general not an attractive investment strategy for the average investor, and particularly not so when the investments are debt financed. The two protected equity notes DnB Global and Dnb Sektor 2000/2006 will here be used as an illustrative case, because of their expected principal importance regarding how complaints in relation to structured products will be treated in the Norwegian

[2] Comparatively, the municipalities’ losses in relation to the Terra-case, one of the largest financial scandals ever to have occurred in Norway have been estimated to approximately 800 MNOK.

[3] While this paper focus on the role of banks in the sale of structured products, there are also other financial institutions that have been distributing these products in Norway, most notably investment firms such as Orkla Finans and Acta Kapitalforvaltning. The financial advisers of Acta in particular have been subject to much criticism in relation to the structured products debate (Bjørndal & Fadnes, 2008). Furthermore, while the banks in most cases have been responsible for the actual design and distribution of the products, other investment firms and banks are normally involved in the production by holding the short positions in the option contracts embedded in the products. For the remainder of this paper however, I will focus on the banks as distributors of these products

legal system in the future. Secondly, it is necessary to analyse how and why the banks were able to convince so many of their customers to invest in what were, in essence, inferior investment and saving products. The specific research questions of this thesis are thus:

**Supporting questions:**

I. Using the Monte Carlo simulation technique, what is the estimated expected return of the two products DnB Global and DnB Sektor 2000/2006?

II. What are the major factors and incentives influencing buyer and seller behaviour in the Norwegian structured product market?

**Main research question:**

III. Is there any evidence that product providers have taken advantage of information asymmetry in the sale of structured products?

## 1.3 Structure of the paper

In order to address these research questions I will in chapter 2 present a framework for analysing structured products. This chapter contains an introduction to the most important components of structured products; bonds and options, as well as a suggestion for how these components and the total structured package can be priced.

Chapter 3 provides an overview of the Norwegian structured products market and its most important players, current regulations and trends.

In the following chapter I will discuss how previous studies have evaluated the two products in question, explain the Monte Carlo simulation technique and use this tool to estimate the expected return on DnB Global and DnB Sektor 2000/2006.

Chapter 5 contains an analysis of how and why structured products have become so popular in Norway; it will examine problems of irrational preferences and information asymmetry, and discuss what incentives and factors have influenced behaviour in the market.

Conclusions and final comments are provided in chapter 6.

# 2. A theoretical framwork for structured products

Structured products are relatively complicated instruments that are difficult for people without an extensive understanding and knowledge of financial markets and derivatives theory to fully comprehend. However, in order to investigate the structured product market and appreciate why these products generally are more attractive for the bank than for the investor, it is crucial to understand the underlying characteristics of the products involved. In this section I will therefore provide a brief introduction to structured products and the individual building blocks that are used to construct these investment strategies.

## 2.1 What is a structured product?

Structured products originally developed to meet specific needs that standardised financial instruments are unable to meet. Although there is no uniform definition, the U.S. Securities and Exchange Commission defines structured products in Regulation C of the Securities Act as “securities whose cash flow characteristics depend upon one or more indices or that have imbedded forwards or options or securities where an investor's investment return and the issuer's payment obligations are contingent on, or highly sensitive to, changes in the value of underlying assets, indices, interest rates or cash flows” (SEC, 2003). When structured products were first marketed they were normally tied to strong, important stock market indices. However, as the products developed they became more frequently linked to quite different reference portfolios; self-composed and industry portfolios, as well as to a range of other underlying assets such as interest rates, currencies, energy contracts and commodities (Loven & Garås, 2008). Hence, structured products give investors a method of gaining specific exposure to a vast range of markets and commodities without actually owning the asset – and thus also an opportunity to invest in asset classes they may have previously considered too risky.

A structured product is created by combining financial instruments with the aim of structuring the cash flows from the packaged investment strategy to meet investor’s risk and return preferences. Most often this is done by combining a guaranteed cash flow, for example a zero-coupon bond or a bank deposit, with a risky derivative such as one or more option or to a lesser extent warrants and swaps. For example, if the investor invests 100 NOK the issuer would simply put enough capital in a risk-free bond so that when interest is compounded the amount will grow to 100 NOK after the pre-determined time-period. The leftover funds are then used to purchase the options or swaps needed to perform whatever the investment strategy is. I have set up a numerical example of how these products may be structured, and this is provided in Figure 2 below. Assume that investor's initial payment is 104, where 4 is used to cover the bank's fees, and 100 is invested in the structured product. The bank deposit is offering a 5 per cent p.a. interest rate and the maturity of the product is in 5 years. The bank will place 78.35[4] in zero-coupon bonds, and use the left-over funds to by options. At maturity the bond will pay out 100. The risk associated with these types of products is related to whether or not the option has a payoff, and if so what the size of this payoff is.

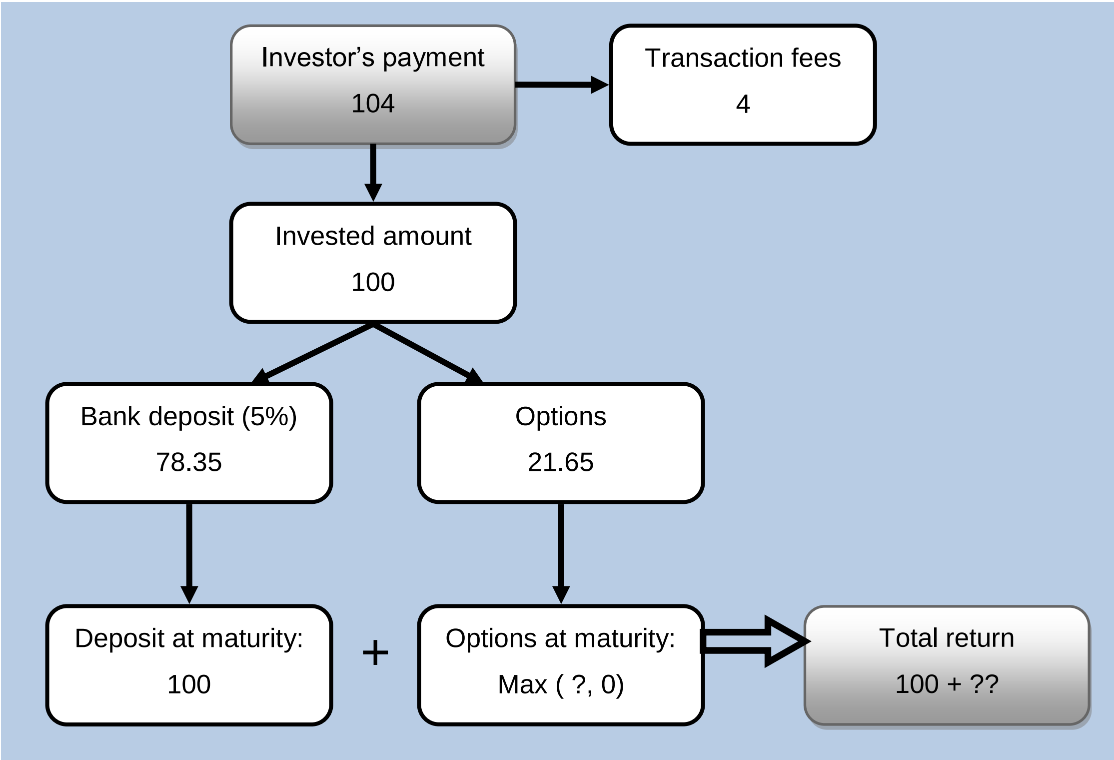



*Figure 1: Creating a structured product*

The investor should in theory be able to perform the same actions by trading in financial markets himself; however the costs and transaction volume requirements involved are often too high to be carried by individual investors.

[4] $100/1.05^5=78.35$

In the Norwegian setting the two most popular structured products are the protected equity note[5] (aksjeindeksobligasjon, AIO) and the market-linked (equity-linked) certificate of deposit (banksparing med aksjeavkastning, BMA). The protected equity note is typically designed to return principal at maturity along with a portion of any gains in one or more pre-determined indices (Laise, 2008). This payoff is constructed by combining a zero-coupon bond with options on the relevant underlying indices. The market-linked certificate of deposit is similar to the principal-protected note, but in this case the guaranteed element is granted by a bank (term) deposit as opposed to a zero-coupon bond. As bank deposits up to 2 million NOK are absolutely guaranteed through the Norwegian Banks' Guarantee Fund, investors do not have to consider credit risk when pricing these investments (Loven & Garås, 2008; Laise, 2008). On the other hand it is necessary to consider the issuer's risk of default when valuing structured products that are based on bonds, as the principal protection here depends on the issuer's ability to meet its obligations.

## 2.2 Components to structured products

Structured products are created through financial engineering, which refers to "the creation and design of securities with custom-tailored characteristics" (Bodie, Kane, & Marcus, 2005, p. 24). The products consist of bundles of risk-free and risky cash flows that are supposedly packaged according to the needs and desires of investors. However, this bundling of primitive and derivative securities can make it quite difficult for the average investor to fully comprehend and assess the risk and return relationship, and thus the value, of the composite security. This is, as I will discuss at a later stage, in fact one of the major criticisms against structured products. In order to accurately estimate the value it is necessary to decompose the packaged product, and evaluate the different components on an individual basis. The sum of values of these separate instruments is then the value of the investment strategy as a whole. In this section I will thus provide a brief introduction to the two most important building blocks of structured products; bonds and bank deposits and options. The material in this section is based on McDonald (2006), Hull (2005) and Bodie, Kane and Marcus (2005).

[5] Also called indexed bond

### 2.2.1 Bonds and bank deposits

Bonds are also called fixed-income securities, and are a type of debt security issued by a borrower who is obligated to make specified payments to the holder over a pre-determined period (Bodie, Kane, & Marcus, 2005). There are two main groups of bonds; coupon bonds and zero-coupon bonds. An investor holding a coupon bond will receive regular coupon payments over the life of the bond, as well as a repayment of the principal or face value of the investment at maturity. Conversely, a zero-coupon bond will provide a payment of face value at maturity only (Bodie, Kane, & Marcus, 2005).

Structured products are most often based on either zero-coupon bonds or bank deposits, which can be valued using the same principles. The price of a zero-coupon bond is shown in Equation 2-1 (Bodie, Kane, & Marcus, 2005):

$$Price = \frac{Face\ Value}{(1+r)^T}$$

Equation 2-1

Where $r$ is the interest rate and $T$ is the time to maturity. With continuous compounding the price is given by:

$$Price = e^{-rT} \times Face\ Value$$

Equation 2-2

Zero-coupon bonds are issued at prices considerably below face value since the investor's return comes solely from the difference between issue price and the payment of principal at maturity. The interest or discount rate of the bond is based on the nominal risk-free rate which incorporates the real risk-free rate of return and a premium to compensate for expected inflation. Since the bonds issued by the provider of the structured product are normally not riskless, the discount rate will also embody an additional premium which reflects both the default risk of the issuer and other bond-specific characteristics such as liquidity, tax attributes, and call risk.

### 2.2.2 Options

Derivatives are securities whose prices are derived from the prices of other securities. Options are one of the most common classes of derivatives, and are simply contracts that provide the buyer a right, but not an obligation, to perform some kind of specified action

(Hull J. C., 2005). There are two main categories of options; a call option is a contract that gives the buyer the right to buy the underlying asset at a predetermined price, and similarly a put option gives the buyer the right to sell the underlying security. Investors will either buy or sell (write) options. The buyer of the option contract is holding a long position in the option, whereas the seller is holding a short position. An investor who is holding a long call or a short put will benefit as the price of the underlying asset rises, whereas a short call and a long put profits as the price of the underlying decreases (McDonald, 2006).

It is the buyer of the contract who is in control of the contract; the rights of the buyer are the obligations of the seller. When a buyer profits from a contract, the seller will carry an equivalent loss. Since the buyer decides whether or not to buy, the seller cannot make money at expiration. In order to entice the seller to enter such a contract, the buyer must pay an initial price, or premium. Thus we can think of the option contract as a method of buying or selling insurance against high or low asset prices (McDonald, 2006).

The majority of structured products are designed so that the principal of the investment is protected all the while the investor partakes in some proportion of the gains of the underlying asset. This is the equivalent of owning a zero-coupon bond while holding a long call option; the bond constitutes as such the guaranteed component, whereas the call option may or may not generate a positive return to the investor. Although other option positions are rarely used as the only derivative component of structured products, they are more frequently used in combination with the long call, which enables the holder to achieve a payoff both if the price of the underlying increased or decreased beyond (or up to) a certain point (barrier). A more detailed description of how barriers are designed can be found in McDonald (2006), and valuations of marketed products that includes barriers can be found in Bøe (2007) and Loven and Garås (2008). Since the long call is the most important type of option in relation to structured investments, I will focus on this type when explaining the payoffs from options. However, in order to gain a more comprehensive understanding of the long call it is important that the reader is familiar with the key terms used to describe options. I have therefore provided a brief introduction to option terminology in Table 1 which is based on McDonald (2006, p. 32).

| | |
|---|---|
| Spot price | The current market price of an asset. |
| Strike price/ Exercise price | The strike price is the contract price of the option contract, and is the amount that can be exchanged for the underlying asset. |
| Exercise | The act of exchanging the strike price for the underlying asset at the terms specified in the contract. |
| Expiration | The date by which the option must either be exercised or it becomes worthless. |
| Exercise style | The circumstances under which an option holder has the right to exercise an option. The two most common exercise styles are "European" and "American". |
| European option | An option that can only be exercised at expiration |
| American option | An option that may be exercised at any time during its life |

*Table 1: Option terminology*

**The long call**

The long position of a call option gives the owner the right, but not the obligation, to buy the underlying asset on or before the expiration date by paying the fixed exercise price. As the buyer is not obligated to buy the underlying asset he will only exercise the option when the payoff is positive, that is, when the spot price at expiration is higher than the contract price (strike). The algebraic expression for the payoff profile of a long call is thus (Hull J. C., 2006):

$$C_T = max[0,\ S_T - K]$$

*Equation 2-3*

Where $C_T$ is the payoff from the option at time $T$, $S_T$ is the spot price at maturity and $K$ is the strike price of the option contract. The payoff can be represented graphically as follows (Hull J. C., 2005):

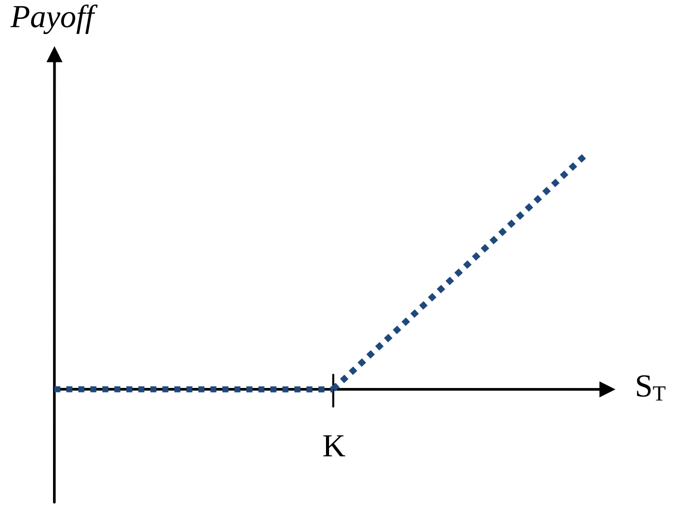



*Figure 3: Payoff from a long call*

The horizontal axis shows the spot price at time T, and the vertical axis shows the payoff at expiration. When the current spot price is higher than the exercise price K, the buyer receives a positive payoff from the option, i.e. he buys the underlying asset from the option writer (seller) at the contract price K and receives a payoff by selling it immediately in the market. The profit from the long call is determined by the initial premium that the buyer paid in order to obtain the contract (McDonald, 2006). The size of this premium is the price of the call and can be determined (estimated) using several different option-pricing methods, some of which are further explained in chapter 2.3. The call option profit is calculated by deducting the future value of the option premium from the payoff to the contract. This is represented graphically in Figure 4 (McDonald, 2006):

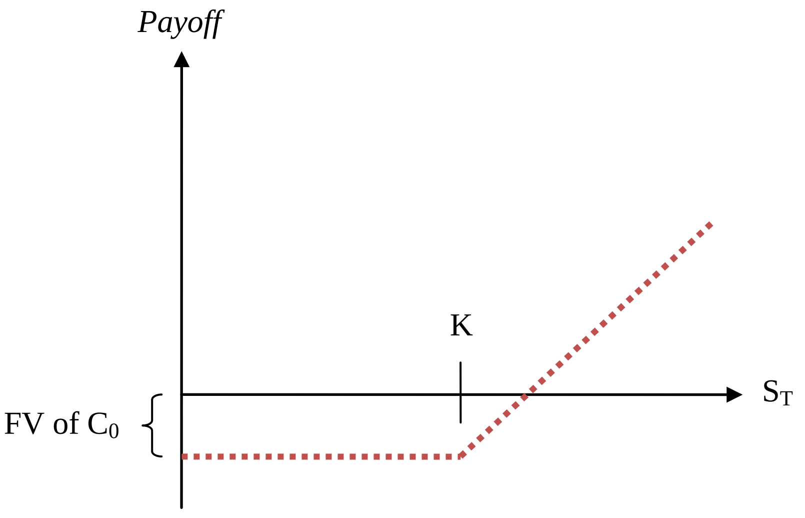



*Figure 4: Profit on a long call*

**Asian options**

Asian options are frequently used in structured product design, and we will see later that the two DnB products were no exception. The payoff of these options depends upon some average of the underlying asset prices over the life of the option. Since the value of the option at expiration depends on the path by which the stock arrived at its final price, we say that Asian options are path-dependent (McDonald, 2006). When the settlement of an option is based on the average price it is called an Asian tail; for instance a market-linked CD may have a payoff that is based on the average daily stock price over the last 30 days. Asian tails are quite common in structured products as they reduce the volatility, and thus the value, of the option component – I will return to this issue in chapter 2.3.

There are eight ($2^3$) basic kinds of Asian options, depending on whether it is a call or a put, how the average is computed, and whether the average is used in place of the spot price of the underlying asset or the exercise price of the option (McDonald, 2006).

The average can be defined either by arithmetic or geometric average. Although arithmetic averages are most common in practice, they are mathematically inconvenient[6]. The geometric average is much simpler in this regard, and there are easy pricing formulas for geometric Asian options. The arithmetic average is defined as (Bodie, Kane, & Marcus, 2005)

$$A(T) = \frac{1}{N}\sum_{i=1}^{N} S_{ih}$$

Equation 2-4

Here the stock price is recorded every *h* periods from time 0 to T, which means there are $N = T / h$ periods. The geometric average is defined as (Bodie, Kane, & Marcus, 2005)

$$G(T) = (S_h \times S_{2h} \times \ldots \times S_{Nh})^{\frac{1}{N}}$$

Equation 2-5

Asian options where the payoffs are dependent on the arithmetic average price of the underlying asset are the most common type of derivatives used in Norwegian structured products (Loven & Garås, 2008). Since there are no closed-form approximation formulas for pricing arithmetic Asian options, it can be quite difficult to estimate their value – especially for an inexperienced private investor. Monte Carlo simulation is one of the most common techniques used to evaluate these options, and I will explain this tool later in the paper.

## 2.3 Valuing structured products

Structured products can as I explained earlier be evaluated by analysing the different building blocks of the compound asset. The valuation can be seen as a two-step process: First we need to analyse the prospectus and understand what components have been used to structure the security, i.e. we need to identify whether the product consist of a zero-coupon

[6] Since the sum of lognormal variables is not lognormally distributed.

bond, bank deposit, and the amount and type of derivatives used. When we know what portfolio of individual asset would provide us with a cash flow identical in magnitude and timing to the cash flow from the structured product, we can take advantage of the most important yet commonsensical assumption of derivatives pricing; the idea that if two different investments generate the same payoff, they must have the same cost. This is called no-arbitrage pricing, and implies that the market price of the structured product must equal the price of this replicating portfolio, which is the sum of the values of the individual financial assets in the portfolio. If these price relationships do not hold there are possibilities for arbitrage, which means that profit can be generated without risk and with no net investment of funds (McDonald, 2006).

Hence, if we understand how to value the individual components of the replicating portfolio we can value the structured product. We already discussed the pricing of zero-coupon bonds in chapter 2.2.1, and in the next section we will see how options are most commonly valued, namely by using the Black-Scholes formula.

### 2.3.1 The Black-Scholes formula for valuing options

Fischer Black and Myron Scholes published in 1973 a paper that revolutionised the theory and practice of finance (McDonald, 2006). They presented a formula, known as the Black-Scholes formula, for computing the theoretical price of a European call stock option (Black & Scholes, 1973). Later that year, Merton (1973) contributed to establishing the standard no-arbitrage restrictions on option prices, which significantly generalised the Black-Scholes formula. It is outside the scope of this paper to explain the formula in detail, but detailed analysis can be found in Hull (2006) and McDonald (2006).

The Black-Scholes formula for a European call option on a stock that pays dividends at the continuously compounded rate $\delta$ is (McDonald, 2006):

$$C_0 = Se^{-\delta T}N(d_1) - Ke^{-rT}(d_2)$$

*Equation 2-6*

Where

$$d_1 = \frac{\ln(S/K) + (r - \delta + \frac{1}{2}\sigma^2)T}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

The Black-Scholes formula makes a number of assumptions about both the economic environment and how the stock price is distributed (McDonald, 2006). The formula assumes that the risk-free rate is known and constant, that there are no transaction costs or taxes, and that it is possible to borrow at the risk-free rate and short sell without accruing costs. Further assumptions include that continuously compounded returns on the stock are normally distributed and independent over time; that the volatility of returns is known and constant; and future dividends are known. Many of these assumptions can be relaxed, however, and the Black-Scholes formula is widely accepted as one of the most important models for option pricing (McDonald, 2006).

Equation 2-6 gives the price of an option with a stock paying continuous dividends as the underlying asset. The Black-Scholes formula can be expanded to calculate the price of options on stocks paying discrete dividends, futures and currencies; for a description of how this is done see for instance Bjerksund, Carlsen and Stensland’s (1999) approach to valuing indexed bonds. Next we will use the Black-Scholes formula to explore the factors that affect the value of an option, and thus the value of the structured product.

### 2.3.2 Factors affecting option prices

Distributors and producers in Norway have, as we will discuss more at a later stage, been accused of frequently including design features that reduces the value of structured products. If we are to understand how this is the case, we need to briefly discuss what factors influence the value of a structured product. In Equation 2-6 we observe that there are six variables that affect the price of an option; the stock price, the strike price, time to expiration, volatility, the risk-free interest rate and dividends. Table 2 presents a summary of the effect on the price of an option for an increase in each of these variables while the others remain fixed. The table is from Hull (2005, p. 206).

| *Variable* | *European call* | *European put* | *American call* | *American put* |
|---|---|---|---|---|
| Current stock price | + | - | + | - |
| Strike price | - | + | - | + |
| Time to expiration | ? | ? | + | + |
| Volatility | + | + | + | + |
| Risk-free rate | + | - | + | - |
| Dividends | - | + | - | + |

+/-/? indicates that an increase in the variable causes the option price to increase/decrease/relationship is uncertain.

*Table 2: Factors affecting option prices*

**The current stock price and the strike price, $S_0$ and $K$**

If a call option is exercised, the payoff is the amount by which the stock price exceeds the strike price. The call option will thus become more valuable as the stock price increases and less valuable when the strike price is higher.

**The time to expiration, $T$**

An American call option becomes more valuable as the time to expiration increases, because time provides the option owner with more opportunities to exercise the option. In the case of European calls, however, the effect is not always clear-cut. While these options will normally become more valuable as the time to expiration increases, there are exceptions to the rule. For instance, consider two options with a stock as the underlying asset; one which will expire in one month and the other in two months. Suppose a large dividend is announced for payment six weeks from now. The dividend payout will cause the stock price to decline at the ex-dividend date, and thus reduce the value of the two-month option relative to the shorter-lived one.

**The volatility of the underlying asset, $\sigma$**

Volatility measures the uncertainty of the return realised on an asset. The chance that a share will do extraordinary well or exceptionally poorly becomes greater when volatility is higher. These two outcomes normally offset each other for the owner of the stock, but this is not the case for an option owner. The holder of a call benefits from the increased chance of abnormally high returns, but do not have to carry the extra down-side risk as the maximum loss on an option is limited to the price. The value of a call option will therefore increase as volatility increases.

**The risk-free interest rate, *r***

When the interest rates in an economy increase, the required return investors tends to increase, while the present value of future cash flows received by the option holder decreases. The two effects combined would normally increase the value of the call option. Note that the interest rate effect is explained under an 'all else equal' assumption; a rise in interest rates would generally imply a fall in stock prices, and so the net effect could be to decrease the value of the call option.

**The dividends expected during the life of the option, *δ***

The price of a call option is negatively related to the size of any expected dividends, as dividend reduce the stock price on the ex-dividend date.

# 3. The Norwegian structured product market

The massive criticism regarding the design, marketing and sale of structured products is not a phenomenon purely related to the current financial crisis. Several of Norway's most respected scholars in the area of financial economics voiced their concerns already in the late 1990s, at a time when structured products were rapidly becoming one of the most popular investment classes of the mass market (Aasnes & Semmen, 1997; Bjerksund, Carlsen, & Stensland, 1999). However, it was not until an increasing number of products approached maturity that the general opinion turned; a rise in public displeasure was seen as many products proved to be relatively poor investments. This chapter will provide an overview of the history, size, and regulation of the Norwegian market for structured products.

## 3.1 History of structured products in Norway

Structured products were first introduced to the Norwegian market in the 1980s, when DnC and Bergen Bank offered bonds that included an option element to professional and institutional investors (Kredittilsynet, 2008). The first market-linked bond was issued in April 1992 and was designed for professional or institutional investors. The return was dependent on the development of the Dax 30 (Germany) and the S&P 500 (USA) indices, and the investor would lose capital should the return on the underlying be negative (Axelsen & Rakkestad, 1999). The vast majority of bond issues directed towards private investors include a guarantee than ensures that the principal, or invested amount, is repaid at maturity. These types of products became available to the mass market in 1997, when among others DnB NOR and Nordea offered equity-linked deposits to private investors. The majority of banks introduced structured products to their clients between 1998 and 2000.

In a recent survey by the Financial Supervisory Authority of Norway, Kredittilsynet, banks generally reported that they were introduced to the concept of structured products by different product suppliers, for instance Terra and Pareto (Kredittilsynet, 2008). DnB NOR was one of three banks that introduced these products on their own initiatives, after observing similar products in international markets. Furthermore, Kredittilsynet found that out of 15 surveyed banks, only one bank reported that the decision to offer structured products were made by the board. This decision was mainly taken by the CEO across the remainder of the sample.

Over the years since first becoming available to the mass market, structured products quickly became one of the most popular investment strategies of private investors, who in 2006 owned more than 90 per cent of outstanding investments in these products (Almklov, Tørum, & Skjæveland, 2006). Figure 5 show the nominal value in millions of NOK of outstanding investments in structured products from December 2002 to December 2008 inclusive, based on numbers from Statistics Norway (SSB, 2009a; SSB, 2009b). The red field represents indexed bonds whereas the blue field denotes market linked certificates of deposit. We observe that the outstanding investment in indexed bonds was reasonably stable between 2002 and 2005, but has declined sharply since March 2006. Market-linked certificates of deposit experienced exceptional growth in the years 2002-2006. Surprisingly, the value of outstanding investments stabilised first in December 2006, and remained relatively stable until March 2008 after which it has fallen rapidly.

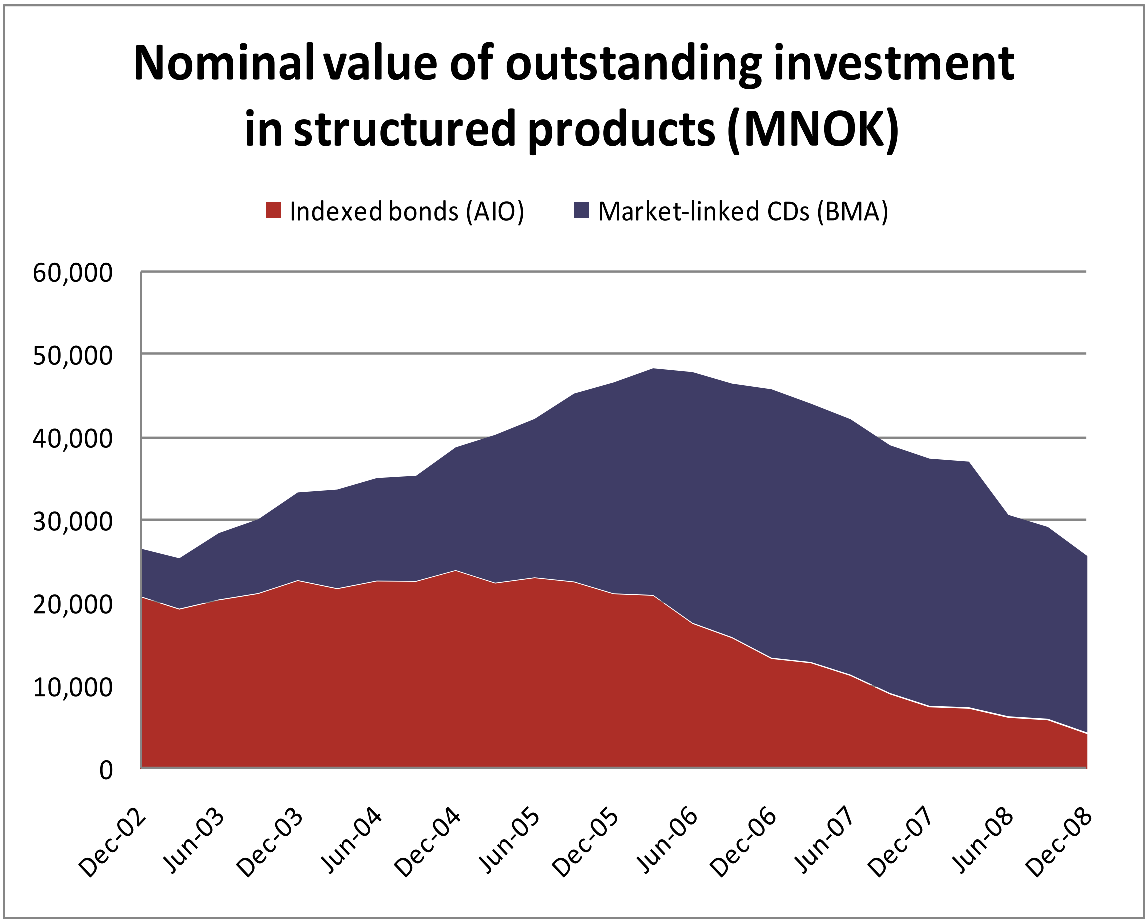



*Figure 5: Nominal value of outstanding investment in structured products*

The development in market-linked CDs is more obvious in Figure 6, which show the nominal value in MNOK of total outstanding investment between 2000 and 2008. The investment for the years 2000-2002 are here interpolated based on Axelsen and Rakkestad (1999) and numbers from Statistics Norway (SSB, 2009a).

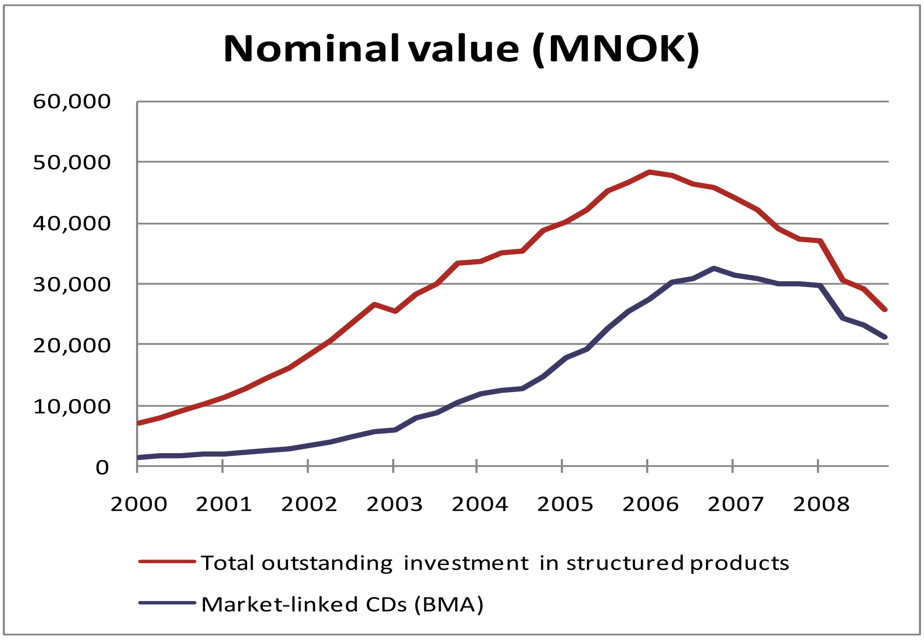



*Figure 6: Total outstanding investment 2000-2008*

Approximately 24.9 billion NOK are still invested in different structured products as of January 2009 (SSB, 2009a). Kredittilsynet estimates that 80 per cent of the total investment is geared, that is, loan-financed (Kredittilsynet, 2008). The proportion of outstanding investments in structured products that is debt-financed is shown in Figure 7.

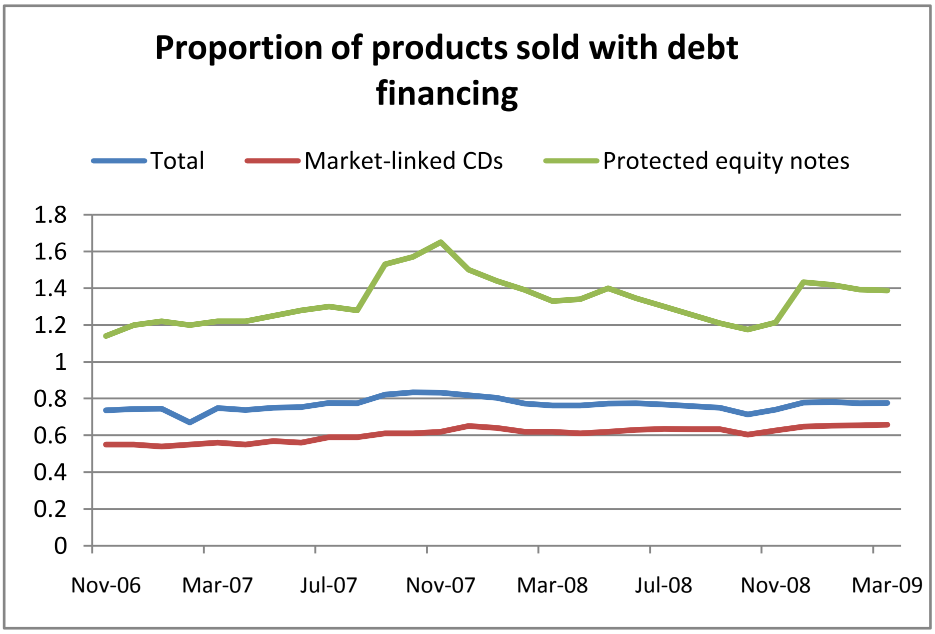



*Figure 7: Proportion of products that are debt financed*

The data is collected from the SSB website (SSB, 2009c). The figure shows that the banks have debt financed more than 100 per cent of protected equity notes sold; the reason for this being that daughters or branches of foreign banks in Norway[7] lend to investors buying notes issued by other divisions of the corporation.

According to the Norwegian Consumer Council (Forbrukerrådet) the gearing of structured products is a fairly Norwegian phenomenon, and while similar products have been sold by banks in Sweden and Denmark they have not offered loan-financing in conjunction with the investment (Forbrukerrådet, 2009a). In a meeting with the Swedish Banker's Association in April 2008, representatives from the two banks Swedbank and Handelsbanken were questioning whether the idea of structuring products disappear if the investment is geared. This has been one of the major criticisms against the sale of these products in Norway. Most banks have offered to finance up to 100 per cent of the invested amount, arguing that gearing the investment increases the potential for high returns. I show how we can expand the example from Figure 2 to include the effects of debt-financing in Figure 8. The presentation assumes that the investor has borrowed 100 per cent of the payment required for the investment, and that there are no fees involved in acquiring the loan[8]. The interest on the loan is 6 per cent, and the product and loan expires in 5 years. The investor will borrow 104 from the bank, use 4 to cover product transaction fees and 100 to invest in the actual product. Again, 78.35 is invested in a 5 per cent zero-coupon bond, and 21.65 is used to purchase options. At maturity the bond will pay 100, the loan repayment is 139.18[9], and the payoff from the option is uncertain. From the figure it becomes clear that the investor require a cash flow of nearly 40 from the options in order to break even. This constitutes an 81 per cent return from the option over the 5 year investment period, which equals a 12.6 per cent p.a. return[10].

[7] Such as Nordea (daughter of foreign bank) and Fokus (branch of foreign banks)

[8] In practice the bank frequently charge a fee for providing the loan.

[9] $104 \times 1.06^5 = 139.18$

[10] $21.65 \times (1 + x)^5 > 40 \ \rightarrow x > 0.126$

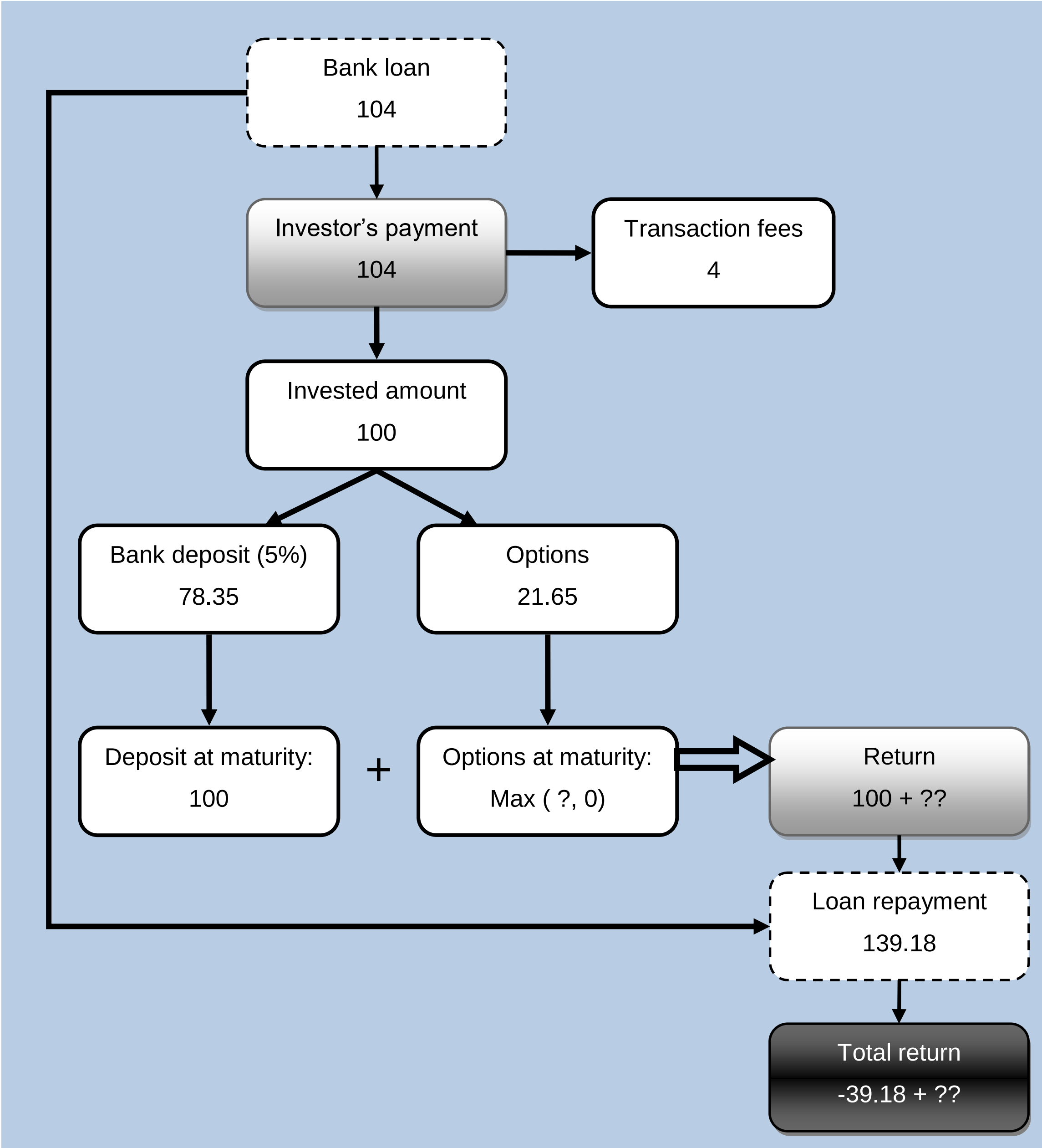



*Figure 8: Debt-financing a structured product*

Financing structured products have been viewed as a particularly profitable activity for the banks. The default risk is limited to interest payments only, since a high proportion of the borrowed amount is placed in a bank deposit or zero-coupon bond. Nonetheless, most banks have still charged a considerable interest margin on these loans (Koekebakker & Zakamouline, 2006; Bøe, 2007; Johnsen, 2008).

In addition to the problem of debt-financing structured products, two more issues have been subject to heavy criticism. The first problem is that the products are designed and built in such a way that it is very difficult for the investor to accurately evaluate the product that is being purchased. Analyses in several master theses from NHH show that pricing structured products is relatively demanding, and it is unreasonable to except that the average private investor have the necessary financial background and theoretical knowledge to estimate the correct price on these products (Bøe, 2007; Loven & Garås, 2008; Solvær, Steinnes, & Stølen, 2005; Haugo, 2007). Furthermore, experts have argued that banks have offered unnecessary complicated products in order to both confuse customers with respect to the real value of the investment package, and to present complex elements as both safer and more profitable than what they really are (Staavi, 2006). Several academic analyses have shown that the theoretical price of the option-element of structured products is much lower than what has been declared in the product prospectuses (Bjerksund, 2008; Solvær, Steinnes, & Stølen, 2006; Koekebakker & Zakamouline, Forventet avkastning på aksjeindeksobligasjoner, 2006; Lie, Lindset, & Lund, 2005) – this constitutes a hidden fee or margin beneficial to the supplier. A change in the regulation in 2006 ensured that the product provider is obligated to inform of the size of this hidden fee in its marketing materials (Kredittilsynet, 2006), however it is still uncertain whether these sizes accurately represent the fees that the customer truly pays (Bøe, 2007; Loven & Garås, 2008).

The second issue relates to the marketing and sale of the products. Experts argue that product providers have taken advantage of the product complexity and financial illiteracy of their customers in the sale of structured products (Ormseth, 2007). The product prospectus often promises a return equivalent to the stock market, at a risk that compares to a normal bank account – which is at best an inadequate representation of reality. While structured products if designed appropriately can be useful hedging instruments and interesting investment strategies for the right investor, product providers have incorporated design elements that have a negative impact on the value of the packaged product. One important feature of the design is that the underlying index is nearly always a pure price index, which implies that it is not adjusted for dividends. If the investment was actually placed in the underlying index the investor would receive the dividends as they accrued, but the holder of an option does not actually own the stock and will as such not receive dividend payments. Dividends are thus an expense to the option owner, and will therefore reduce the value of the packaged product.

We have seen that the value of an option is dependent on volatility, which is why many product providers incorporate features that reduce volatility in the design of structured products. A common example is the use of Asian tails where the strike price or the price at expiration is calculated as an average of a pre-specified number of observations. Averaging reduces the volatility of the stock price at expiration, and thus the value of the average structured product decreases with the number of stock prices used to compute the average (McDonald, 2006).

In most Norwegian banks the sale of structured products has been carried out by financial advisers that should more accurately be referred to as sellers (Døskeland, 2009). Critiques have questioned whether many of these sellers posit the necessary knowledge or comprehension to explain how investor's return is calculated at expiration, or how the products can be priced and evaluated. Examples of aggressive selling to credulous customers have frequently been quoted in the media and some financial advisers have even been known to visit homes for the elderly in order to find potential investors (Finansdepartementet, 2009; Bergo, 2007; Berge & Forseth, 2009). These advisers have furthermore often received volume-dependent bonuses when selling structured products (Kredittilsynet, 2008).

With the introduction of new regulation we have seen an improvement both in what information is included in prospectuses and how this information is presented (Loven & Garås, 2008). However, the majority of issues that have expired to date were not covered by these regulatory changes, and many customers are lodging complaints both with the supplying banks and with Bankklagenemnda. The prevailing litigation involving DnB NOR is expected to be of great importance to many private investors around the country, and some experts have estimated that class actions and customer compensations will cost Norwegian banks more than 14 billion NOK (Stranden, 2009). I will provide a brief summary of relevant regulation later in this chapter, and I will also present the details involved in the case of the two DnB NOR products. However before discussing these issues let us briefly look at the realised return on structured products marketed in Norway over the last decade.

### 3.1.1 Realised return on structured products

Over the last few years several academic analyses and reports have shown that both the expected and realised return on the structured products offered in the Norwegian market have been dismal. Kredittilsynet asked 15 banks to report realised return on every product that was issued and matured before the third quarter of 2007 (Kredittilsynet, 2008). The banks were required to report the return for investments that were 100% equity financed, and for investments that was debt financed with 80%. The number of observations reported was 350 for equity financed products, and 218 for leveraged investments.

The respondents reported an arithmetic average return of approximately 4% per annum for the investments that were equity financed, however the spread of returns was significant, as portrayed in Figure 9

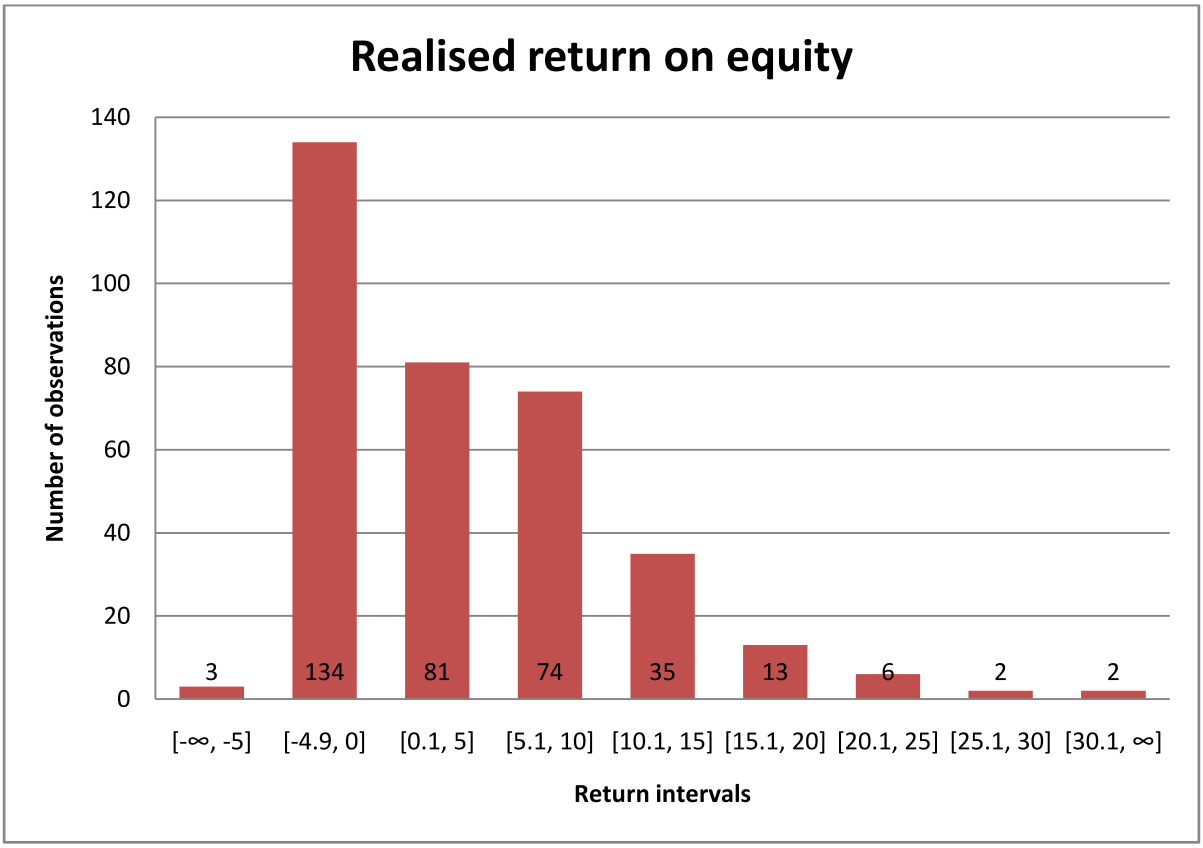



*Figure 9: Realised return equity financing, not including transaction costs.*

The figure shows that 137 of the products or nearly 40% had an annual return of 0% and lower, whereas 62% of the products (218 observations) had a return below 5% cent per annum[11]. In comparison, the average interest rate on a 5-year governmental bond for the period 1997-2007 was 5.24% per annum (Norges Bank, 2009). Most of the structured products that were included in the survey had a limited downside risk, since the principal of the investment was guaranteed through a certificate of deposit or zero-coupon bond; this explains the relatively short tail on the left-hand side of the distribution. Transaction fees

[11] The products reported in the survey expired between 2001 and 2007, and was issued after 1997.

normally amount to between 1 - 4% of invested amount dependent on product, volume and customer relationship, and have not been included in the diagram.

The reported arithmetic average return on leveraged structured products was 2% per annum. The distribution of returns on products financed with 80% debt capital is shown in Figure 10.

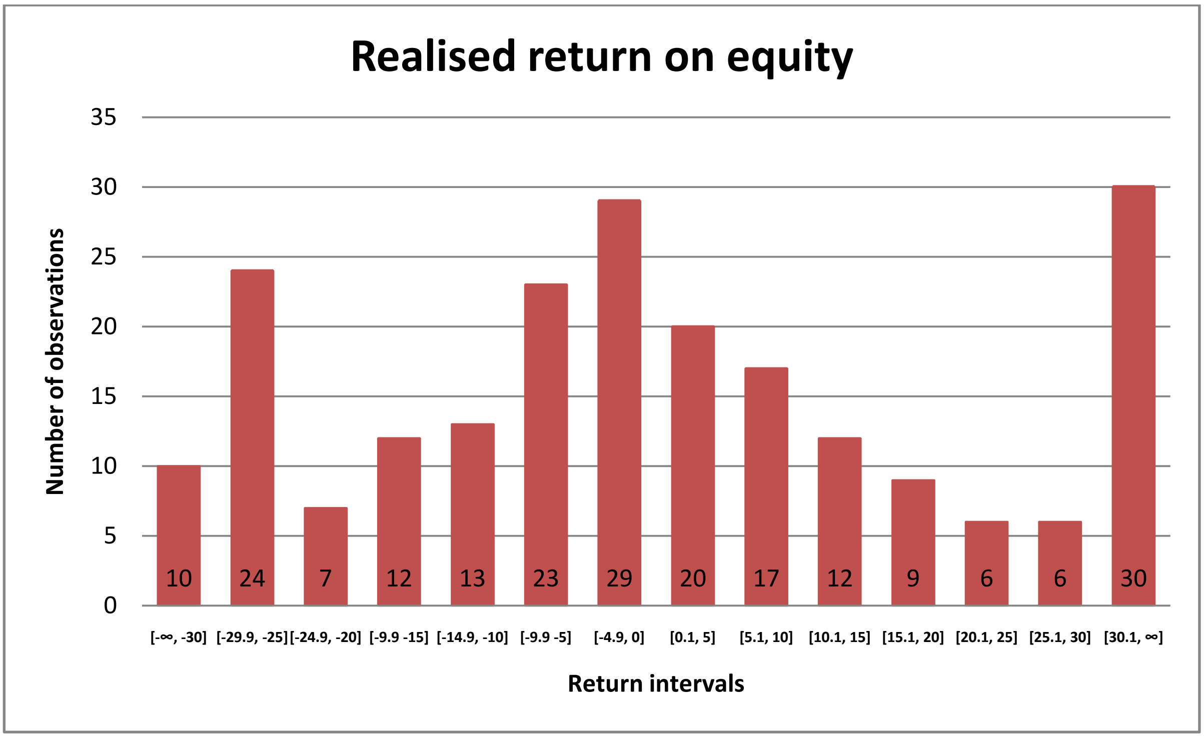



*Figure 10: Realised return on equity for 80 per cent leveraged investment in structured products, not including transaction costs.*

The figure shows that 118 out of 218 or approximately 54% of products had zero or negative yearly return. Nearly 14% of products had a return on equity above 30%, while 5% of products suffered losses of more than -30% per annum[12]. Returns would have been slightly lower if transaction costs were included in the diagram. The diagram further reflects the fact that leveraged structured products have the potential for returning high returns, in accordance with what banks have argued when defending the sale of structured products. However, debt-financing also increases the chance of significant losses when product return

[12] These were likely products where only a proportion of the invested amount was guaranteed through the bond/deposit element.

is zero or negative, and many believe that banks in general have not adequately informed their customers in this respect (Bjerksund, 2008).

Koekebakker and Zakamouline (2007) found that the arithmetic average return for 270 indexed bonds that expired in the period between 1997 and 2007 was 2.16% per annum, whereas the geometric average was 1.58%. Only 36.3% of the bonds had a positive total return, and hence 63.7% of products expired worthless during the period. The divergence in the numbers reported by Kredittilsynet (2008) and Koekebakker and Zakamouline (2007) is probably related to differences in the methodologies employed. Koekebakker and Zakamouline received extensive criticism from DnB NOR, which have claimed that the methodology is erroneous, particularly with respect to the bench-mark evaluation of the products. See Brattlie, Kleiven and Jordheim (2007) and Koekebakker and Zakamouline (2007) for more on this quarrel.

## 3.2 Regulation of the market

The above discussion of realised return on structured products implies that these financial instruments probably did not constitute appropriate investment strategies for the average investor. When we also consider that banks were simultaneously operating as distributors and advisers we sense that there is a strong need for regulation in the market. The Financial Supervisory Authority of Norway (Kredittilsynet) has received criticism for reacting to slowly to the unfavourable practices in relation to the sale of structured products, and it was only after a sustained pressure from the media and independent experts that Kredittilsynet finally acknowledged the serious problems in this market (Ørjasæter, 2009). In this section I will briefly present the changes in relation to regulating the structured product market, and how recent actions from regulators have practically put a stop to the sale of these products.

The first Circular issued by Kredittilsynet (No. 4/2004) contained guidelines on what information should be disclosed in connection with the sale of structured products. However, a Circular only describes the recommended norms, and does not as such have regulatory power. This issue was later replaced by Circular No. 15/2006, which furthermore included guidelines on and documentation requirements of the investment advice service in relation to the sale of these products (Høgsand, 2008; Kredittilsynet, No. 15/2006). Kredittilsynet issued simultaneously amendments to the Regulations concerning financial institutions' sale and advisory services regarding structured products, which came into effect

January 1, 2007. The new legislation focuses on investor protection corresponding to the Market in Financial Instruments Directive (MiFID), which harmonised the regulatory regime for investment services across the European Economic Area member states (Kleven, 2008). The purpose of these regulatory actions was to provide consumers with more and better information in relation to several aspects of structured products, including expected return, risk elements and inherent costs (Høgsand, 2008).

The regulatory actions so far did not however prevent the banks from selling debt financed structured products to unsuitable investors (Sparre M. R., 2009d), and Kredittilsynet found it necessary to issue another Circular (No. 4/2008), which informed financial institutions about changes to the current regulation on the duty of disclosure in relation to the sale of structured products. The amendments made the sale of structured products more difficult by posing a number of new requirements on the banks, including that these and other complex products should not be sold to customers who cannot be regarded as professional investors. Kredittilsynet also advised the financial institutions against offering debt financing when selling structured products, based on the “historically low returns on equity capital and the risk of significant losses for the customers on this form of financing” (Kredittilsynet, No. 4/2008). As expected, the new Circular led to a considerable reduction in the sale of structured products to the general public, and a large number of banks have now stopped the sale, distribution and debt financing of these products (Kleven, 2008).

## 3.3 Structured product trends

When Kredittilsynet conducted its survey in late 2007, nearly 90 per cent of the banks were still offering structured products, however Circular 4/2008 that came into effect on March 1, 2008 limited as we have seen the banks’ opportunity to sell these these products. This regulation, as well as the substantial negative attention structured products have received in the media, has put a full stop to the popularity of these products in Norway. However, the banks have been quick to come up with alternative products, most notably so-called warrants, to compensate for the lost income. The similarities to the conventional structured products are striking, especially when considering that a warrant is a call option written by a company on its own stock[13]. When warrants are exercised the company issues more of its

[13] The term also refers more generally to an option issued in fixed supply.

own stock and sells them to the option holder at the strike price. While this new invention are not covered to the same extent as the protected equity note and market-linked CDs in the current regulation, it is still very complex instrument, and potential investors should exercise caution when offered to buy such products. For more on warrants see for example Loven and Garås (2008), McDonald (2006) or Hull (2005).

# 4. Evaluating DnB Global and DnB Sektor using the Monte Carlo simulation technique

In the two previous chapters I presented a framework for understanding options and structured products, and provided an overview of the Norwegian structured product market. These two chapters should enable the reader to understand and analyse a real world case, namely the high profile debate concerning the two structured products DnB Global and DnB Sektor 2000/2006; two products which have received particular focus in Norway over the last couple of years. In the next chapter I will use the results obtained to illustrate the issue of asymmetric information in the structured product market.

In 2006, Koekebakker and Zakamouline (2006) used the Monte Carlo method to analyse two structured products and found that the expected return on debt financed investments were negative. DnB Global and Sektor represented typical structured products; they seemed neither specifically poorly designed nor extraordinary complicated as far as structured products go. Armed with the conclusions from Koekebakker and Zakamouline, private investor Ivar Petter Røeggen raised a complaint to Bankklagenemnda, who only after pressure from the Minister of Finance Kristin Halvorsen agreed to hear the case. Because of the complexity involved, Bankklagenemnda named an independent expert, Professor Thore Johnsen, to assist in the evaluation of the two products. A conclusion was reached only earlier this year, when Bankklagenemnda decided in favour of the client, recommending that the bank restore him to his original financial position. The bank has decided not to comply with Bankklagenemnda's recommendation and Røeggen, with the assistance of the Norwegian Consumer Ombudsman (Forbrukerrådet), is currently preparing a court case against DnB NOR. It is expected that the case will be pursued all the way to the Supreme Court (Andersson, 2009; Sparre M. R., -Skal bli moro å kjøre dem i retten, 2009c).

In this chapter I will discuss the characteristics of the two products, before analysing how first Koekebakker and Zakamouline, and later DnB NOR Markets and Thore Johnsen evaluated these products, with a particular focus on the choices of input parameters. I will then explain how the Monte Carlo simulation technique can be applied to value structured products, before I apply this model using the parameters chosen by DnB and Johnsen. The results are discussed in section 4.4.

## 4.1 The products

DnB Global and DnB Sektor 2000/2006 are two protected equity notes issued on November 24, 2000 by Den norske Bank ASA with expiration on November 24, 2006. The two notes combine a zero-coupon bond issued at par value, and a long position in a call option. At expiration the bond holder receives the principal and an additional return dependent on the development in the underlying stock index (DnB Markets, 2000a; DnB Markets, 2000b).

The underlying asset of the DnB Global 2000/2006 index bond is a basket of three stock indices as presented in Table 3:

| Area/country: | Sub index: | Weight: |
|---|---|---|
| Europe | Dow Jones EURO STOXX 50 | 0.50 |
| USA | Standard & Poor's 500 Index | 0.25 |
| Japan | Nikkei 225 | 0.25 |

*Table 3: Underlying indices of DnB Global 2000/2006*

The additional return on DnB Global is calculated by multiplying the principal *P* with the return factor *RF* and the weighted sum of the relative changes in the sub indices DJ Euro Stoxx50, S&P 500 and Nikkei 225. The relative change of each index is given by the difference between the value at expiration *T* and value when issued *t*, divided by the issue value. If the weighted sum of the relative changes in the three sub indices is negative, the return is set to zero. The algebraic expression for this return is given in Equation 4-1 (DnB Markets, 2000a):

$$Return =$$
$$P \times RF \times max\left[\left(\frac{DJ\ Euro\ Stoxx\ 50_T - DJ\ Euro\ Stoxx_t}{DJ\ Euro\ Stoxx_t} \times 0.5\right) + \left(\frac{S\&P\ 500_T - S\&P\ 500_t}{S\&P\ 500_t} \times 0.25\right) + \left(\frac{Nikkei\ 225_T - Nikkei\ 225_t}{Nikkei\ 225_t} \times 0.25\right), 0\right]$$

*Equation 4-1*

The value at time t of each sub index is determined by the arithmetic average of the values over two trading days; 24 November 2000 and 22 December 2000. The value at time T is defined as the arithmetic average of 13 monthly observations of the index value between November 2005 and November 2006 inclusive. The return factor is 105 per cent (1.05).

The underlying index of the DnB Sektor 2000/2006 index bond is a basket of three stock indices as described in Table 4:

| Sector: | Sub index: | Weight: |
|---|---|---|
| Healthcare | Dow Jones STOXX Healthcare | 1/3 |
| Telecommunications | Dow Jones STOXX Telecom | 1/3 |
| Bank | Dow Jones EURO STOXX Bank | 1/3 |

*Table 4: Underlying indices of DnB Sektor 2000/2006*

As in the previous case, the additional return on DnB Sektor is calculated by multiplying the principal *P* with the return factor *RF* and the weighted sum of the relative changes in the sub indices DJ Stoxx Healthcare, DJ Stoxx Telecom and DJ Euro Stoxx Bank. If the weighted sum of the relative changes in the three sub indices is negative, the return is set to zero. The algebraic expression for this return is given in Equation 4-2 (DnB Markets, 2000b).

$$Return =$$
$$P \times RF \times max\left[\left(\frac{Healthcare_T - Healthcare_t}{Healthcare_t} \times \frac{1}{3}\right) + \left(\frac{Telecom_T - Telecom_t}{Telecom_t} \times \frac{1}{3}\right) + \left(\frac{Bank_T - Bank_t}{Bank_t} \times \frac{1}{3}\right), 0\right]$$

Equation 4-2

The value at time t of each sub index is determined by the arithmetic average of the values over three trading days; 24 November 2000, 22 December 2000 and 24 January 2001. The value at time T is defined as the arithmetic average of 19 monthly observations of the index value between May 2005 and November 2006 inclusive. The return factor is 100 per cent (1.0).

The underlying indices for both Global and Sektor are price indices only, and are as such not adjusted for dividends. The returns on the indices are further calculated in local currency, which ensures that the investor is not exposed to currency risk.

The transaction fee is dependent on customer relationship and volume as shown in Table 5. The fee is determined based on the total investment if the customer purchased both products. The note was sold in shares of NOK 10,000.

| Invested amount | | Ordinary customers | Program customers |
|---|---|---|---|
| From | To | | |
| NOK 10,000 | NOK 1,000,000 | 4.50 % | 3.75 % |
| NOK 1,010,000 | NOK 2,000,000 | 3.50 % | 2.90 % |
| NOK 2,010,000 | NOK 3,000,000 | 2.50 % | 2.10 % |
| NOK 3,010,000 | NOK 5,000,000 | 1.50 % | 1.00 % |
| NOK 5,010,000 | ∞ | 0.50 % | 0.40 % |

*Table 5: Transaction fees for DnB Global and DnB Sektor 2000/2006 from (DnB Markets, 2000a).*

DnB Global and Sektor are representative examples of structured products marketed in Norway at the start of the century (Lindset, 2008). The products are designed with price averages both at the start and at the end of the investment periods, and take as such advantage of both time and asset diversification in attempts to decrease volatility. In 2006, Koekebakker and Zakamouline was the first to conduct and publish results from a thorough examination of these two products, and I will now present the results from their analysis.

### 4.1.1 Estimating expected return: Koekebakker and Zakamouline

Only a limited number of academic analyses had been conducted on the return potential of structured products marketed in Norway before Koekebakker and Zakamouline presented their results in 2006. They found that the expected returns of the two products tested, DnB Global and DnB Sektor, were only marginally higher than the risk-free rate. Gearing the products would cause the investor's expected return to be negative, that is, according to the authors' estimations investors would on average lose money when buying these guaranteed products.

In their analysis, Koekebakker and Zakamouline (2006) used the Monte Carlo simulation technique, which I shall return to later in this chapter. In order to estimate the expected return, the authors had to make assumptions on the values of a range of different parameters; the risk-free rate in Norway and in relevant foreign countries, the interest rate on loans, as well as the expected return (risk premium and dividend yield), volatility and correlation of the relevant underlying indices. I will now briefly explain the assumptions underlying this analysis, before presenting the results achieved.

**Assumptions about the expected returns**

*Risk premium:* Koekebakker and Zakamouline (2006) base their assumptions of expected returns on the underlying indices on the data on historical risk premiums presented by

Dimson, Marsh and Staunton (2000) in *The Millennium book – a century of investment returns*. The geometric average risk premium in the period between 1900 and 2000 in USA and Japan was 5.8% and 6.7% respectively. The weighted geometric average risk premium for a group of European countries[14] for the same period was 5.3%. Koekebakker and Zakamouline (2006) use these numbers as the future expected risk premium, but emphasise that these are fairly high estimates, as the risk premium in general have decreased after the Second World War due to (among other factors) decreasing political risk.

The risk premiums for the industry specific indices underlying the DnB Sektor bond was estimated using the Capital Asset Pricing Model (see for instance Bodie, Kane and Marcus (2005), chapter 9). The relevant beta (β) estimates were based on 60 monthly observations of the sub indices and market portfolio prior to November 2000. The risk premiums for STOXX Healthcare, STOXX Telecom and STOXX Bank were 4.23%, 5.72% and 5.56% respectively.

*Dividend yield:* The estimates for dividend yields are based on monthly observations for the last 5 years prior to November 2000 for the different country and industry indices, and lies within the range 0.9% to 2.84%[15].

*Expected return:* The total expected return is then calculated by subtracting the expected dividend yield from the sum of the relevant risk-free rate and the risk premium for each sub index. Koekebakker and Zakamouline (2006) assumes an expected per annum return of 8.58% for Euro STOXX50, 10.27% for the S&P 500 and 6.15% for the Nikkei225. STOXX Healthcare, Telecom and Bank have expected returns of 8.15%, 9.12% and 8.07% respectively.

**Assumptions about correlation and volatility**

The estimates for volatility $\sigma_i$ and correlation $\rho_{ij}$ between the different sub-indices was again based on historical numbers; the last 60 monthly observations prior to the issuance of the bond. Koekebakker and Zakamouline's estimates can be found in Table 6:

---

[14] Belgium, Denmark, France, Germany, Ireland, Italy, the Netherlands, Spain, Sweden and the United Kingdom.

[15] The dividend yield for each index is presented in Table 7 later in the chapter.

| | Correlation | | | Volatility |
|---|---|---|---|---|
| **Global** | **Euro STOXX50** | **S&P 500** | **Nikkei 225** | **σ** |
| Euro STOXX50 | 1.0000 | | | 19.16% |
| S&P 500 | 0.6689 | 1.0000 | | 16.26% |
| Nikkei 225 | 0.4017 | 0.5092 | 1.0000 | 20.36% |
| **Sektor** | **STOXX Healthcare** | **STOXX Telecom** | **STOXX Bank** | |
| STOXX Healthcare | 1.0000 | | | 19.97% |
| STOXX Telecom | 0.5048 | 1.0000 | | 22.36% |
| STOXX Bank | 0.6342 | 0.6204 | 1.0000 | 20.36% |

*Table 6: K&Z's assumptions about correlation and volatility*

**Results**

Koekebakker and Zakamouline completed 100,000 iterations in their simulations, and found that the expected return on an equity financed investment is 7.72% and 7.16% for Global and Sektor respectively, at the 4.5% transaction fee level (investments up to NOK 1,000,000). If the investor only pays 0.5% of the invested amount in transaction fees, the expected per annum returns are 8.42% and 7.90%. In comparison, the rate on a risk-free governmental bond for the same period was 6.30%, meaning that the products had expected risk premiums of 0.9% and 2.1%. The authors also show the effects of gearing the two products; the expected return when 100% debt financed was -1.31% for Global and -1.84% for Sektor including a 4.5% transaction fee. Hence, the investors should expect to lose money on average when investing in the two products.

The results from Koekebakker and Zakamouline have been critically important in the complaint against DnB to Bankklagenemnda, and are likely to play a key role also in the upcoming court case.

## 4.1.2 Estimating expected return: DnB NOR Markets

In a letter to Bankklagenemnda 4 July 2007, DnB NOR Markets conducted their own analysis and valuation of the two structured products (Johnsen, 2008)[16]. DnB does not give an explanation of the models employed to evaluate the products, but the parameters chosen are as follows:

[16] I have not been able to access this document, however it is thoroughly presented in Johnsen (2008) and my analysis is thus based on his discussions.

*Interest rates:* The interest rates chosen by DnB are only marginally different from Koekebakker and Zakamouline; the latter choose to base the analysis on 6-year government bond yields, whereas the former employs swap rates. DnB use a NOK swap rate of 6.77% per annum, and a weighted average foreign rate of 4.77% for Global and 5.44% for Sektor. The interest rates on loans to finance the investments are set to 8.51%.

*Dividend yield:* While Koekebakker and Zakamouline use historical 5-year dividend yields, DnB argue that the yield over the last 12-months prior to the issue date is more relevant, since the short term rates are more relevant than historical rates when evaluating the size of future dividends. DnB estimates the weighted average dividend yield for Global and Sektor to 0.96% and 1.97% respectively.

*Risk premiums:* DnB derive arithmetic continuously compounded risk premiums from their assumption on index volatility, by assuming a constant Sharpe ratio[17] of 0.25, meaning that the excess returns on the underlying index portfolios are related to the risk of the portfolio. Converting the continuously compounded returns to p.a. returns DnB employs an annual arithmetic risk premium of 6.38% for Global and 7.82% for Sektor. The equivalent geometric premiums are 3.45% and 3.49% respectively.

*Volatility:* Koekebakker and Zakamouline use historic volatility and correlations for the last 5 years prior to the issuance of the bonds. DnB on the other hand, argue that implicit volatility is more relevant when valuing the products, that is, the volatility that reflects the market price of the options. The bank asserts that the implicit volatility of the options they purchased were 23.6% for Global and 28.6% for Sektor, which are fairly high numbers from an historical point of view.

**Results**

DnB Markets report an expected return of 10.19% (9.48%) and 10.54% (9.82%) per annum for transaction fees of 0.50% (4.50%) for Global and Sektor respectively for an equity financed investment. For leveraged investments (100% debt financing), they estimate the expected annual return to 2.48% (1.50%) for Global and 2.98% (2.02%) for Sektor.

[17] The Sharpe ratio is expressed as $S = \frac{E(R-R_f)}{\sigma}$

### 4.1.3 Estimating expected return: Johnsen

The two valuations presented to Bankklagenemnda so far report highly contradictory expected returns on the two products, confirming the fact that structured products are complex instruments which are difficult for the average investor to evaluate. Since none of the members of Bankklagenemnda had the required knowledge to financially analyse the product prospectuses[18], they called on an external, objective expert to make a thorough analysis on their behalf. Thore Johnsen, professor in finance at NHH was thus brought in to assist Bankklagenemnda in their decision making process, and his case report was submitted in August 2008. In the following section I will present the assumptions and results obtained by Johnsen, but first let us examine the model he used to evaluate the products since the choice of model can greatly influence the results obtained.

**The model**

Johnsen (2008) employs a simplified analytical model when estimating the expected return on the two products. The model is developed from the notion that the price of the call option $C_0$ is equal to the discounted value of the expected option return at maturity $E(C_T)$, using the appropriate risk-adjusted interest rate $r_c$:

$$C_0 = \frac{E(C_T)}{(1+r_c)^{T_F}}$$

*Equation 4-3*

Where

$$E(C_T) \equiv E\{max[S_T^* - G; 0]\}$$

*Equation 4-4*

Where $S_T^*$ is the value of the index at maturity expressed as a percentage of the initial value, and where the asterisk denotes that both the starting and maturity values may have been calculated as an average of several observations. The discounting rate equals the Norwegian risk free rate plus a risk premium that reflects the systematic risk of the option return. $T_F$ is the effective time to maturity, which is shorter than the nominal time to maturity because of the average prices employed. Assuming that the stock prices follow a lognormal stochastic process, the expected return on the option is

[18] In fact, Bankklagenemnda first deemed that such evaluations were too complicated for the board members and thus declined to hear the case, but changed their minds after pressure from the Minister of Finance Kristin Halvorsen.

$$E(C_T) = N(d_1^*) \times E[S_T^*] - N(d_2^*) \times G$$

Equation 4-5

Where $N(x)$ is the cumulative normal distribution; the expected return on the stock index (in percentage of the initial value) is given by

$$E[S_T^*] = \left[\frac{(1 + r_u + RP)}{(1 + \delta)}\right]^{T_F}$$

Equation 4-6

Where

$$d_1^* = \frac{ln\left(\frac{E[S_T^*]}{K}\right)}{\sigma^T} + \sigma\sqrt{T_\sigma}$$

$$d_2^* = d_1^* - \frac{1}{2}\sigma\sqrt{T_\sigma}$$

The expected yearly return on the index equals the total return $(1 + r_u + RP)$ adjusted for the dividend yield, $r_u$ is the risk free rate and RP is the arithmetic risk premium for the underlying index. The volatility for the index is scaled using the effective maturity.

While this simplified model is useful in estimating the expected return on the products from the investor's perspective, Johnsen acknowledge that it is inadequate when evaluating how the bank initially priced the options. For instance, Equation 4-6 would require knowledge about the bank's perception of the risk premium RP and dividend yield δ of the index. Thus, when evaluating the price and implicit costs of the two products, Johnsen employs standard option pricing theory and the Black & Scholes formula.

When calibrating his model against the parameters chosen by Koekebakker and Zakamouline, Johnsen (2008) finds that his model generates consistently higher expected returns (0.80% and 0.72%) than their simulation results. He attributes the difference to the assumption of additive lognormality. The model provides consistently lower returns than those reported by DnB NOR Markets, however the difference is relatively small being approximately -0.2% and -0.4% for Global and Sektor respectively. Johnsen (2008) further argue that out of the difference in results between Koekebakker/Zakamouline and DnB NOR Markets, approximately one percentage point of the difference in reported expected returns are attributed to the model employed.

I have explained the model chosen and how it may affect the results produced. Let us know turn to the assumptions and parameters employed by Johnsen in his analysis.

**The assumptions**

*Interest rates:* Johnsen based his expected return estimates for the two products on DnB NOR’s swap rates, as he believes that these were most likely used at the initial pricing of the products.

*Dividend yield:* Johnsen agreed to some extent with DnB NOR’s argument that short term dividend yields are more important than longer term ones, but emphasised that this assumes that the investor is more concerned with a short term future dividend yield. Since dividend yields were unusually low in 2000 because of the dot-com bubble and the investment period was 6 years, Johnsen argued that a normal historical level for expected dividend yields is more relevant. He thus used a dividend yield of 1.5% for Global and 2.0% for Sektor.

*Risk premium:* Johnsen used a geometrical risk premium of 3.0% for Global and 2.7% for Sektor. The premiums were found by scaling the widely accepted 3% long term geometric risk premium for the global market portfolio according to the weighted beta $\beta$ values for Global and Sektor of 1 and 0.9 respectively.

*Volatility and correlation:* While Johnsen agreed that implicit volatility is in many cases more relevant than historic volatility, he commented that the volatility levels employed by DnB are high. In an appendix he showed that the Global and Sektor portfolios have experienced a significant reduction in overall volatility relative to that of the underlying indices in the previous 6-year period because of consistently low correlations between the indices. Since the indices have experienced increasing volatility over the couple of years, Johnsen regarded 18% and 22% volatility for Global and Sektor respectively to be relatively realistic estimates for the expected future implicit volatility.

In an appendix, Johnsen graphed the development in 6-year correlation between the underlying indices from 1993 onwards. His calculations for the Global portfolio in particular are significantly lower than the 5-year historic correlations estimated by Koekebakker and Zakamouline. Johnsen’s results yield 6-year correlations of approximately 0.39 and 0.28 between EuroSTOXX 50 and the S&P 500 and Nikkei 225 indices respectively, and a correlation of 0.06 between S&P 500 and Nikkei 225. These graphs are shown in Appendix 1.

**Results**

Johnsen (2008) found that the annual expected return for 0.5% and 4.5% transaction fee is 7.77% and 7.07% for Global and 7.82% and 7.12% for Sektor when the investment is equity financed. The expected return on a fully leveraged investment is -1.13% and -2.32% per annum for Global and -1.05% and -2.23% for Sektor. Thus, Johnsen supports the results by Koekebakker and Zakamouline that the expected return on debt financed investments is negative.

### 4.1.4 A comment on the methodologies employed

Johnsen (and most likely DnB NOR Markets[19]) through the adaption of simplified models assume that the distribution of returns for both Global and Sektor is lognormal, whereas Koekebakker and Zakamouline only assume lognormality for the three sub-indices included in each of the two products. The sum of lognormal distributions is not necessarily lognormal, and Johnsen's argue that both his and DnB NOR's estimations *overvalue* the price and the expected return for the two products relative to Koekebakker and Zakamouline's simulation results, because simplified models are used in the analyses. Any model implemented in order to analyse structured products is sensitive to the assumptions made when identifying the relevant input parameters in the model. However, we have seen that the final result from the analysis can also be highly sensitive to the model employed. Thus, it would be useful to see whether the results provided by Johnsen and DnB Markets really overestimate the expected return on the two equity protected notes, and the likely size of this overrating. The Monte Carlo simulation technique is widely regarded as the most accurate method for evaluating complex derivatives such as the option component of many structured products (Boyle P. P., 1977; Hull J. C., 2006; McDonald, 2006); so the question arises of whether the parameters chosen by DnB Markets in particular would continue to generate positive expected returns when used in a Monte Carlo simulation? Another important aspect is to see what the probability distribution of these returns would look like. If the simulation would yield negative expected returns it would seriously weaken the bank's position and argument in the upcoming court case. I will provide the result from my simulations based on DnB's input parameters shortly, but I will first provide a thorough explanation of the Monte Carlo method in order for the reader to understand why this particular method is believed superior in the area of complex option pricing.

[19] Johnsen calibrates his model against the parameters employed by DnB NOR and find that his model produces consistently lower expected returns than the model adapted by the bank. The differences are however quite small; about 0.2% for Global and 0.4% for Sektor.

## 4.2 Monte Carlo simulation

Monte Carlo simulations were first developed and used by physicists as a method of measuring the characteristics of neutrons in 1930 (Husebø, 2002). Monte Carlo methods have since then found wide application in a range of different fields, including chemistry, design and visuals, telecommunication, games, mathematics and finance. In finance the method is used to price assets whose prices are not readily determined by analytical means (Benninga, 2008). In 1977, Boyle (1977) developed a Monte Carlo simulation method for solving option valuation problems. The method provided a useful supplement to the approaches proposed by Black and Scholes (1973) and Cox and Ross (1976). Monte Carlo simulation is particularly useful in relation to the valuation of path-dependent options, such as Asian and barrier options, whose price depends not only on the terminal value of the underlying asset, but also on the path of the prices by which the terminal price was reached (Benninga, 2008).

The Monte Carlo method for option pricing involves simulating future stock prices using a random number generator. These simulated prices are then used to compute the discounted expected value of the option. Monte Carlo valuation is performed using the risk-neutral distribution, meaning that we assume assets on average earn the risk-free rate, and we then discount the expected payoff using the risk-free rate. The concept of risk-neutral valuation is familiar from the binomial option pricing model, and more on this option pricing method can be found in Cox, Ross and Rubinstein (1979), McDonald (2006) and Hull (2006).

**A description of stock price behaviour**

In the previous section we saw that the very essence of a Monte Carlo valuation is to be able to simulate scenarios for how the stock price will evolve in the future. Hence it is crucial to understand how the stock price can be modelled. While the Monte Carlo valuation of a structured product is a central part of this thesis, the main aim is to analyse and discuss whether the bank has taken advantage of its superior informational position in the sale and marketing of structured products. Hence, a thorough explanation of how stock prices are modelled in financial mathematics is outside the scope of this paper. However, since the Monte Carlo method assumes that the stock price can be modelled as a stochastic process, I will briefly explain why this is the case, before we return to the description of the Monte Carlo method for option pricing.

In reality, stocks are traded when the relevant stock exchange is open and the stock price is only recorded when an actual trade has been completed; stocks are traded in discrete time. Furthermore, many stock exchanges require that the trading is conducted according to certain intervals, for instance in steps of 10 cents. These factors imply that the stock price is a discrete variable, however when stock prices are modelled in the financial literature we assume that the stock price is a continuous variable. It is also normal to assume that stock prices follow a random walk, a thought that was first formulated by Samuelson (1965). The random walk theory proclaims that stock prices should reflect all available information in efficient markets, and the price is thus equally likely to move up or down in response to new information[20] (McDonald, 2006). Since we assume that stocks move up or down in a random, unsystematic manner we can model the stock price as a stochastic process (Bøe, 2007). A stochastic process is a random process that is a function of time (McDonald, 2006).

In the Monte Carlo simulation, I assume that the stock price follows an Itô process known as geometric Brownian motion. In essence, it means that instead of assuming that stocks move up and down completely at random, we include a positive drift term in the process, accounting for the fact that we expect that stocks will increase in value over time. The process is described in equation Equation 4-7:

$$S_{t+\Delta t} = S_t e^{\left[(r-\delta)-\frac{\sigma^2}{2}\right]\Delta t+\sigma\epsilon\sqrt{\Delta t}}$$

Equation 4-7

To see an explanation for how the process in Equation 4-7 is derived, see for instance Loven and Garås (2008). For more information on stochastic processes, see for example Cox and Miller (1965), Hull (2006) or McDonald (2006)

### 4.2.1 The Monte Carlo method

In this section we will see how the protected equity notes Global and Sektor can be evaluated using the Monte Carlo method. Both these notes are contingent on a portfolio of three stock indices. The first step is thus to estimate the correlation of returns for the three indices. Let

$\rho_{xy}$ denote the coefficient of correlation between index x and y. The correlation between the three sub indices can be presented by the matrix sigma:

$$\sum = \begin{bmatrix} 1 & \rho_{12} & \rho_{13} \\ \rho_{21} & 1 & \rho_{23} \\ \rho_{31} & \rho_{32} & 1 \end{bmatrix}$$

*Equation 4-8*

When we have estimated the correlation matrix we can simulate price paths for the three underlying indices. If the indices were uncorrelated we could simply simulate three uncorrelated paths, but to simulate price paths for correlated assets we need to use Cholesky decomposition, which is the decomposition of a symmetric, positive-definite matrix into the product of a lower triangular matrix and its conjugate transpose (Bøe, 2007). That is, we need to find

$$C = \begin{bmatrix} c_{11} & 0 & 0 \\ c_{21} & c_{22} & 0 \\ c_{31} & c_{32} & c_{33} \end{bmatrix}$$

*Equation 4-9*

so that when $C$ is multiplied with its transpose $C^T$ the resulting matrix is the same as $\Sigma$ (Bøe, 2007):

$$\begin{bmatrix} c_{11} & 0 & 0 \\ c_{21} & c_{22} & 0 \\ c_{31} & c_{32} & c_{33} \end{bmatrix} \times \begin{bmatrix} c_{11} & c_{21} & c_{31} \\ 0 & c_{22} & c_{32} \\ 0 & 0 & c_{33} \end{bmatrix} = \begin{bmatrix} 1 & \rho_{12} & \rho_{13} \\ \rho_{21} & 1 & \rho_{23} \\ \rho_{31} & \rho_{32} & 1 \end{bmatrix}$$

*Equation 4-10*

This equation is solved by writing a function in Excel using Visual Basic for Applications (VBA). This macro can be found in Appendix 2.

For each time $t_k$ we want to simulate we need to generate 3 random numbers (one for each index) and transform them to standard normally distributed variables $Z_i(t_k)$. These random variables then need to be adjusted for the correlation between the price paths of the three indices (Loven & Garås, 2008). Using the matrix found in the Cholesky decomposition, the correlated random standard normally distributed variables $z_i(t_k)$ can be found from (Koekebakker & Zakamouline, 2006):

$$\begin{bmatrix} z_1(t_k) \\ z_2(t_k) \\ z_3(t_k) \end{bmatrix} = \begin{bmatrix} c_{11} & 0 & 0 \\ c_{21} & c_{22} & 0 \\ c_{31} & c_{32} & c_{33} \end{bmatrix} \times \begin{bmatrix} Z_1(t_k) \\ Z_2(t_k) \\ Z_3(t_k) \end{bmatrix}$$

*Equation 4-11*

The variables $z_i(t_k)$ are used in the MC simulation of the price paths for the three indices, which we saw earlier follows the stochastic process:

$$S_{t+\Delta t} = S_t e^{\left[\left(\mu_i - \delta_i - \frac{1}{2}\sigma_i^2\right)\Delta t + \sigma_i \sqrt{\Delta t} z_i(t_k)\right]}$$

Equation 4-12

Given the price paths for the three sub indices, we can calculate the return on the option for each trial in the Monte Carlo simulation. The return on the option equals (Koekebakker & Zakamouline, 2006):

$$C = max\left[\sum_{i=1}^{3} w_i \frac{S_i^{expiration} - S_i^{start}}{S_i^{start}}; 0\right]$$

Equation 4-13

Where $w_i$ represents the weights for each sub index, $S_i^{start}$ is the arithmetic average of prices at the beginning of the life of the product (Strike):

$$S_i^{start} = \frac{1}{m+1}\sum_{k=0}^{m} S_i(t_k)$$

Equation 4-14

And $S_i^{expiration}$ is the arithmetic average of prices at expiration

$$S_i^{expiration} = \frac{1}{n-l+1}\sum_{k=l}^{n} S_i(t_k)$$

Equation 4-15

Equiations 4-11 to 4-15 are repeated up to the required number of trials by running the macro CalculateOption(), which was written in VBA and can be found in Appendix 2.

We can now calculate the expected return and standard deviation for the Monte Carlo simulation. The expected return is the average of the expected returns for the simulation estimates. The standard deviation for each simulation equals (Loven & Garås, 2008):

$$\sigma_v = \sqrt{\sum_{j=1}^{m} \frac{[V(S_0,0)^j - V(S_0,0)]^2}{m-1}}$$

Equation 4-16

Where $V(S_0,0)^j$ is the price estimates for price path k.

The standard deviation for the total simulation is

$$\sigma_m = \frac{\sigma_v}{\sqrt{m}}$$

Equation 4-17

And the 95% confidence interval for the simulation is

$$\mu - \frac{1.96 \times \sigma_m}{\sqrt{m}} < V < \mu + \frac{1.96 \times \sigma_m}{\sqrt{m}}$$

Equation 4-18

### 4.2.2 Improving the efficiency of Monte Carlo methods

The procedure above is described as a 'naïve' Monte Carlo, since no attempt has been made to reduce the variance of the simulated answer for a given number of trials. While I adhere to the standard Monte Carlo technique in my simulations, McDonald (2006) discusses two main methods to achieve faster, more accurate MC valuations:

**The control variate method**

The idea of the control variate method is to estimate the error on each trial by using the price of a related option that does have a pricing formula. The variance reduction from the control variate method can be dramatic but in our case difficult to employ. The option components of Global and Sektor are quite complicated; with three underlying indices and averaging of both starting and maturity price. While the results from DnB and Johnsen could have served as control variates, the aim in this case is to test the results from these analyses, which means that this is not an appropriate solution. Also, the results achieved without employing the control variate method will be accurate enough for the purpose of discussing information asymmetries in the market for these products.

**The antithetic method**

This method uses the insight that for every simulated realization there is an opposite and equally likely realization; if we draw a random variable 0.5 we could just as well have drawn -0.5. When we use the opposite of each normal draw we get two simulated outcomes for each random path drawn. However, drawing a random number is often not the time-consuming part of a Monte Carlo valuation; the efficiency gain is achieved because the two estimates are negatively related, and adding them reduced the variance of the estimate. Boyle et al. (1997) find modest benefits from using the antithetic variate method.

For more information on variance reduction methods for Monte Carlo simulations see for instance Boyle, Broadie and Glasserman (1997); Joy, Boyle and Tan (1996) and Fouque and Han (2004).

## 4.3 Expected return on DnB Global and DnB Sektor 2000-2006

In this section I will use the Monte Carlo method to estimate the expected return on Global and Sektor based on the parameters chosen by Johnsen and DnB NOR Markets respectively. Johnsen (2008) note that his model more than likely overvalue the expected return on the products due to the assumption of additive lognormality, and he further argue that this is also the case with the model used by the bank. This assumption occurs because a simplified model treats the underlying portfolio as one asset, as opposed to three correlated sub-indices. Herein lies also the most important problem faced in my simulations; since the simplified models treat the underlying as one asset it is only necessary to make assumptions on variables such as the risk premium and volatility on the portfolio as a whole, instead of finding three sets of variables for the different sub indices. However, we can derive estimations of expectations on the risk premium, volatility and correlations of returns on the three sub indices from the overall assumptions made on the composite portfolio, and I will explain how this can be done in the next section[21].

### 4.3.1 Input parameters

Because we estimate the price paths for the underlying indices using the natural logarithm $e$, we need to convert annualised interest rates to continuously compounded returns before we can use them as inputs in the simulation. Continuously compounded returns can be calculated from annualised rates using the conversion formula (McDonald, 2006):

$$r_{cc} = ln(1 + r_{p.a.})$$

*Equation 4-19*

The assumptions made by Johnsen and DnB NOR respectively with respect to dividend yields, risk premiums and volatility are made on the total of the underlying portfolio. We

[21] While the aim of these simulations is to make estimations based on the parameters assumed by DnB NOR and Johnsen respectively, it is always a risk that the derived numbers to not exactly match the authors' original intentions.

therefore need to investigate what these assumptions would mean for the development in the sub-indices separately.

*Risk free rates*

While Koekebakker and Zakamouline employs yields on 6-year governmental bonds, DnB NOR and Johnsen use swap rates, which are slightly higher than the bond yields thanks to a small credit risk premium (approximately 0.5%). I have altered the individual country rates from Koekebakker and Zakamouline (2006) to reflect this credit premium.

*Dividend yields*

DnB NOR argue that the previous 12-month dividend yields for the indices should be used in the price estimates. The bank found that the weighted average yield for Global was 0.96%, which is approximately equal to my own estimates. The individual index 12-month yields are 0.90% for EuroSTOXX50 (STOXX Limited, 2009), 1.14% for the S&P500 (Damodaran, 2009), and 0.88% for the Nikkei225 (TSE Group, Inc., 2009). When it comes to the sub indices included in the Sektor portfolio, finding individual index dividend yields proved difficult, and I will therefore apply the 1.97% dividend yield estimate to each of the three sub indices.

Johnsen chose to base his estimates on normal historical levels for expected dividend yields, and I will thus apply the 1.50% yield universally to the Global indices and 2.0% for the Sektor indices.

*Index volatility and correlation*

According to DnB NOR, the implicit volatility of the Global and Sektor portfolios were 23.6% and 28.6% respectively. As the products were designed and purchased in times of increasing volatility, it is not abnormal that the implicit volatilities of the products were higher than historical volatility at the time, however from the graphs presented in Appendix 1 we see that these estimates are fairly high in terms of historical volatility, which implies that the premium charged on the call options purchased by DnB must have included a generous profit for the relevant investment bank (Johnsen, 2008). Also, section 8.1.2 shows that the correlations between the sub indices of Global in particular were relatively low, providing a significant diversification effect on the volatility of the overall portfolios. In order to apply the bank's volatilities to the Monte Carlo simulation, we need to estimate the approximate volatility for each sub index. Standard portfolio tells us that the volatility of a portfolio of asset is given by

$$\sigma_p^2 = \sum_i \sum_j w_i w_j \sigma_i \sigma_j \rho_{ij} = \sum_i w_i^2 \sigma_i^2 + \sum_i \sum_j w_i\, w_j \sigma_i \sigma_j \rho_{ij}$$

Equation 4-20

Where $w_i$ is the weight of asset i, $\sigma_i$ is the volatility and $\rho_{ij}$ is the coefficient of correlation between assets i and j (Bodie, Kane, & Marcus, 2005). Thus, in order for the overall volatility to increase, either the volatility of the sub indices or the correlation between them must increase (diminishing the diversification effect), or both. In Appendix 3 I show how the volatility of the portfolios Global and Sektor change when the volatility of the sub indices increase holding correlation constant, and vice versa. It is Johnsen's correlation estimates that determine the initial levels of index correlation. It becomes apparent here that the volatility and or correlation must increase significantly in order for the volatility of the overall portfolio to increase to 23.6%. Obviously, estimating how the bank could have perceived increased portfolio volatility to have been shared between increased sub-index volatility and increased correlation involves some guesswork, but such approximations will suffice for the purpose of this analysis as long as the relationship between volatility and expected risk premium for individual indices and overall portfolio is maintained. Because the bank derives its expected risk premium from the volatility numbers, it is possible to approximate the volatility levels for the indices from the stated expected risk premium. Using this method I estimate that volatilities for EuroSTOXX50, S&P 500 and Nikkei225 increase approximately 55% to 29.45%, 25.89% and 34.6% respectively, which implies that the correlations increase with 50%[22] in order to satisfy Equation 4-20. The volatility and correlation levels chosen for Sektor is summarised in Table 7.

I have also decomposed the volatility levels for Global and Sektor chosen by Johnsen, and the estimations are also presented in Table 7. The correlation are here expected to increase by approximately 40% and 20% percent for the Global and Sektor indices respectively, which entails that we increase volatility with 20% for all indices.

[22] It is clearly a simplifying assumption to deduce that the all the relevant correlations within each portfolio increase by the same percentage, and likewise with respect to the individual index volatility levels. The alternative would be to make expectations on future volatility for each individual index and the correlation between the three, but this requires extensive knowledge regarding the bank's (or Johnsen's) predictions on the development within these sub-indices. The assumptions made above clearly illustrates that we would need to see a significant change in underlying volatility and correlations in order to satisfy DnB's expected volatility of 23.6% and 28.6% respectively, and are sufficient for the purpose of testing the two products.

*Risk premium*

The size of the risk premium and expected return on the underlying indices has a substantial direct effect on the expected option return, see for instance Equation 4-12. The three analyses employ very different risk premiums, which explain a significant amount of the difference in results obtained (Johnsen, 2008, p. 11). Furthermore, the risk premiums also differ by definition and compounding frequency; while both Koekebakker and Zakamouline and Johnsen employ annualised geometric averages, DnB NOR use continuously compounded arithmetic average returns in their calculations.

Equation 2-4 shows the algebraic expression for the arithmetic average, which is simply the sum of a list of numbers divided on the count of that list of numbers. When it comes to investment returns, it only represents the average return achieved in each year of the investment period. The geometric average (Equation 2-5), on the other hand, represents the constant rate of return needed in each year to match actual performance over some past investment period (Bodie, Kane, & Marcus, 2005). The geometric average is as such the superior measure of past performance, and according to Johnsen (2008) it is the geometric risk premium that will be determining the expected option return when the stock price follows a lognormal stochastic process. However, since the geometric return will always be lower than the arithmetic mean, "it constitutes a downward-biased estimator of the stock's expected return in any future year" (Bodie, Kane, & Marcus, 2005, p. 865), and many will as such argue that the arithmetic average return is a better measure with respect to estimating future performance[23]. In order to address this potential for both upward and downward bias in the estimate of expected return, I have conducted two sets of simulations for the products; one using arithmetic average risk premiums and the other employing geometric risk premiums. Conversion between geometric and arithmetic averages can be done through Equation 4-21:

$$r_{geometric} \approx r_{arithmetic} - \frac{1}{2}\sigma^2$$

Equation 4-21

Since DnB NOR derive the risk premiums from their volatility expectations by assuming a 0.25 constant Sharpe-ratio for the underlying portfolio, we can use the same assumption

[23] And since compounding at the estimated arithmetic mean results in an upward bias of future performance, this might not necessarily be such a great measure either (Bodie, Kane, & Marcus, 2005).

when finding the expected risk premium for the individual indices[24]. The risk premiums chosen by Johnsen are employed universally to the sub indices of the Global and Sektor portfolios. The risk premiums for Johnsen and DnB NOR as well as all other parameters employed in the simulation are summarised and compared to Koekebakker and Zakamouline in Table 7. All rates are continuously compounded.

| | DnB Global 2000/2006 | | | DnB Sektor 2000/2006 | | |
|---|---|---|---|---|---|---|
| | Euro STOXX50 | S&P500 | Nikkei 225 | STOXX Health | STOXX Telecom | STOXX Bank |
| **DnB NOR** | | | | | | |
| - Risk free rate | 5.49% | 6.32% | 1.26% | 5.30% | 5.30% | 5.30% |
| - Dividend yield | 0.90% | 1.13% | 0.88% | 1.94% | 1.94% | 1.94% |
| - Geometric risk premium[25] | 3.39% | 3.39% | 3.39% | 3.43% | 3.43% | 3.43% |
| - Arithmetic risk premium | 6.48% | 5.69% | 7.61% | 6.11% | 8.56% | 6.73% |
| - Volatility | 29.45% | 25.89% | 34.60% | 27.14% | 38.05% | 29.90% |
| - Correlation | | | | | | |
| - EuroSTOXX | 1.000 | 0.585 | 0.420 | 1.000 | 0.624 | 0.780 |
| - S&P500 | 0.585 | 1.000 | 0.090 | 0.624 | 1.000 | 0.780 |
| - Nikkei225 | 0.420 | 0.090 | 1.000 | 0.780 | 0.780 | 1.000 |
| **Johnsen** | | | | | | |
| - Risk free rate | 5.49% | 6.32% | 1.26% | 5.30% | 5.30% | 5.30% |
| - Dividend yield | 1.49% | 1.49% | 1.49% | 1.98% | 1.98% | 1.98% |
| - Geometric risk premium | 2.96% | 2.96% | 2.96% | 2.66% | 2.66% | 2.66% |
| - Arithmetic risk premium | 4.70% | 4.70% | 4.70% | 5.20% | 5.20% | 5.20% |
| - Volatility | 22.67% | 19.93% | 26.63% | 21.42% | 29.99% | 23.56% |
| - Correlation | | | | | | |
| - EuroSTOXX | 1.000 | 0.546 | 0.392 | 1.000 | 0.576 | 0.720 |
| - S&P500 | 0.546 | 1.000 | 0.084 | 0.576 | 1.000 | 0.720 |
| - Nikkei225 | 0.392 | 0.084 | 1.000 | 0.720 | 0.720 | 1.000 |
| **Koekebakker and Zakamouline** | | | | | | |
| - Risk free rate | 5.21% | 6.00% | 1.19% | 5.21% | 5.21% | 5.21% |
| - Dividend yield | 2.07% | 1.70% | 0.80% | 1.42% | 1.93% | 2.80% |
| - Geometric risk premium | 5.30% | 5.80% | 6.70% | 4.23% | 5.78% | 5.56% |
| - Volatility | 19.16% | 16.26% | 20.36% | 19.97% | 22.36% | 20.36% |
| - Correlation | | | | | | |
| - EuroSTOXX | 1.0000 | 0.6689 | 0.4017 | 1.0000 | 0.5048 | 0.6342 |
| - S&P500 | 0.6689 | 1.0000 | 0.5092 | 0.5048 | 1.0000 | 0.6204 |
| - Nikkei225 | 0.4017 | 0.5092 | 1.0000 | 0.6342 | 0.6204 | 1.0000 |

*Table 7: Summary of parameters*

[24] In order to maintain the relationship between overall volatility/risk premium and the risk premium/volatility/correlations of the sub indices, I have decreased the Sharpe ratio for the sub indices to 0.22 for Global and 0.225 for Sektor, since the chosen volatility level yielded too high risk premiums as compared to the weighted average stated by DnB NOR. The other alternative, keeping the Sharpe ratio constant while decreasing volatility and increasing correlation would have implied increased correlation levels of more than 150%, which in this context seem implausible.

[25] Geometric risk premium for overall portfolio.

### 4.3.2 Results

The law of large numbers (LLN) will ensure that as the number of simulations increase, the estimate for expected option return will converge towards its true value (Glasserman, 2003). In order to provide an accurate estimation of the expected return on the different products, I have run the Monte Carlo simulations for arithmetic risk premiums with 1,000,000 iterations. When testing the results using geometric expected risk premiums, I completed 100,000 trials. The results from each product/parameter simulation are provided in Appendix 4: Simulation results. These tables show the expected return on the option, the standard deviation of the total simulation, and expected total return at 4.5% transaction fees for both equity and debt financing. Table 8 below provides a summary of the results and probability distributions for each simulation.

| *Summary results* | **KZ** | | **DnB** | | | | **Johnsen** | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Arithmetic RP* | | *Geometric RP* | | *Arithmetic RP* | | *Geometric RP* | |
| | **0.50%** | **4.50%** | **0.50%** | **4.50%** | **0.50%** | **4.50%** | **0.50%** | **4.50%** | **0.50%** | **4.50%** |
| E(Rc) Global | - | - | 67.81% | | 55.79% | | 51.78% | | 46.22% | |
| E(Rc) Sektor | - | - | 80.37% | | 54.92% | | 59.72% | | 45.10% | |
| **Equity financed** | | | | | | | | | | |
| E(R) GLOBAL | 62.39% | 56.10% | 70.35% | 63.83% | 57.79% | 51.75% | 53.60% | 47.72% | 47.79% | 42.13% |
| *Per annum* | 8.42% | 7.70% | 9.28% | 8.58% | 7.90% | 7.20% | 7.42% | 6.72% | 6.73% | 6.03% |
| Probability R<0 | 14.16% | 16.54% | 28.83% | 31.22% | 34.15% | 36.69% | 24.30% | 27.18% | 27.38% | 30.48% |
| Probability R<r | 46.35% | 50.22% | 55.07% | 57.73% | 61.16% | 63.74% | 58.34% | 61.82% | 62.43% | 65.80% |
| Probability max loss | 13.80% | 13.80% | 28.54% | 28.54% | 33.81% | 33.81% | 23.93% | 23.93% | 27.00% | 27.00% |
| E(R) SEKTOR | 57.80% | 51.40% | 79.47% | 72.60% | 54.15% | 48.25% | 58.92% | 52.84% | 46.62% | 41.01% |
| *Per annum* | 7.90% | 7.16% | 10.24% | 9.52% | 7.48% | 6.78% | 8.03% | 7.33% | 6.59% | 5.90% |
| Probability R<0 | 22.10% | 24.90% | 30.19% | 32.40% | 41.26% | 43.73% | 32.28% | 32.28% | 35.25% | 38.32% |
| Probability R<r | 53.50% | 57.10% | 54.13% | 56.56% | 65.73% | 67.92% | 57.31% | 60.44% | 66.59% | 69.44% |
| Probability max loss | 21.70% | 21.70% | 29.90% | 29.90% | 40.94% | 40.94% | 26.10% | 26.10% | 34.90% | 34.90% |
| **Debt financed** | | | | | | | | | | |
| E(R) GLOBAL | -3.14% | -9.24% | 7.15% | 0.62% | -5.47% | -12.00% | -9.68% | -16.21% | -15.53% | -22.06% |
| *Per annum* | -0.53% | -1.60% | 1.16% | 0.10% | -0.93% | -2.11% | -1.68% | -2.90% | -2.77% | -4.07% |
| Probability R<0 | 60.89% | 66.10% | 60.38% | 62.96% | 66.30% | 68.85% | 65.18% | 68.47% | 69.06% | 72.16% |
| Probability R<r | - | - | 76.43% | 78.01% | 81.11% | 82.47% | 84.01% | 85.64% | 86.56% | 88.04% |
| Probability max loss | 13.80% | 13.80% | 28.54% | 28.54% | 33.81% | 33.81% | 23.93% | 23.93% | 27.00% | 27.00% |
| E(R) SEKTOR | -8.30% | -14.00% | 16.32% | 9.79% | -9.14% | -15.67% | -4.34% | -10.87% | -16.70% | -23.23% |
| *Per annum* | -1.43% | -2.48% | 2.55% | 1.57% | -1.58% | -2.80% | -0.74% | -1.90% | -3.00% | -4.31% |
| Probability R<0 | 65.90% | 68.90% | 58.95% | 61.33% | 70.06% | 72.14% | 63.50% | 66.45% | 72.23% | 74.82% |
| Probability R<r | - | - | 73.79% | 75.32% | 82.58% | 83.73% | 81.13% | 82.77% | 87.04% | 88.28% |
| Probability max loss | 21.70% | 21.70% | 29.90% | 29.90% | 40.94% | 40.94% | 26.10% | 26.10% | 34.90% | 34.90% |

*Table 8: Summary of results from simulations for DnB Global and Sektor*

E(Rc) denotes expected call option return. The table also shows probability of negative return, probability of return below the relevant risk free rate (6.77% p.a. for Johnsen and DnB NOR Markets), and the probability of experiencing maximum losses, i.e. the option expires worthless.

**Limitations**

The most significant limitations of the above analysis is that I had to make assumptions on the volatility levels, correlation and expected return on the underlying indices, since both

DnB NOR and Johnsen makes assumptions for the overall portfolios only. However, the parameters that were chosen corresponds with the portfolio parameters chosen by the before-mentioned studies, which implies that the overall results would not have been significantly altered if I had made slightly different assumptions. Also, I have adhered to standard Monte Carlo simulation and have as such not implemented a variance reducing technique. Nevertheless, the results that are provided in Appendix 4 shows that the standard deviation of the simulations were quite small, and the 95% confidence intervals for the expected returns are as such very narrow.

## 4.4 Discussion

Let us first note that when applying geometric risk premiums in the simulations, the expected returns for both products with either Johnsen or DnB's parameters are *negative* when the investments are debt financed. The probability that the investor will have a negative return is between 66-75%, dependent on the fee level and product/parameters combination. The call option embedded in the product will expire valueless with a probability of between 27% and 41%. The Monte Carlo simulation provides consistently lower results than the simplified model employed by Johnsen. The return for DnB NOR's parameters was 7.20% and 6.78% per annum for Global and Sektor respectively, as compared to 9.29% and 9.47% from Johnsen's model. Johnsen estimates the respective returns to be 7.07% and 7.12%, whereas the simulations provide returns of 6.03% for Global and 5.90% for Sektor. These results confirm Johnsen's predictions that his simplified model overvalues the products due to the assumption of additive lognormality. The probability distribution for the DnB NOR simulation is found in Figure 11 and for Johnsen in 12.

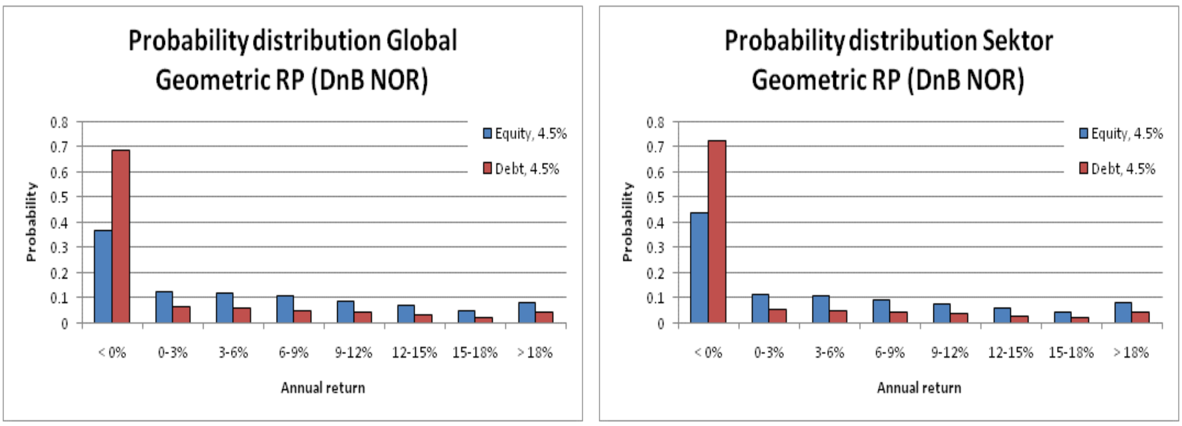



*Figure 11: Probability distributions for Global and Sektor with DnB NOR's parameters and geometric RP*

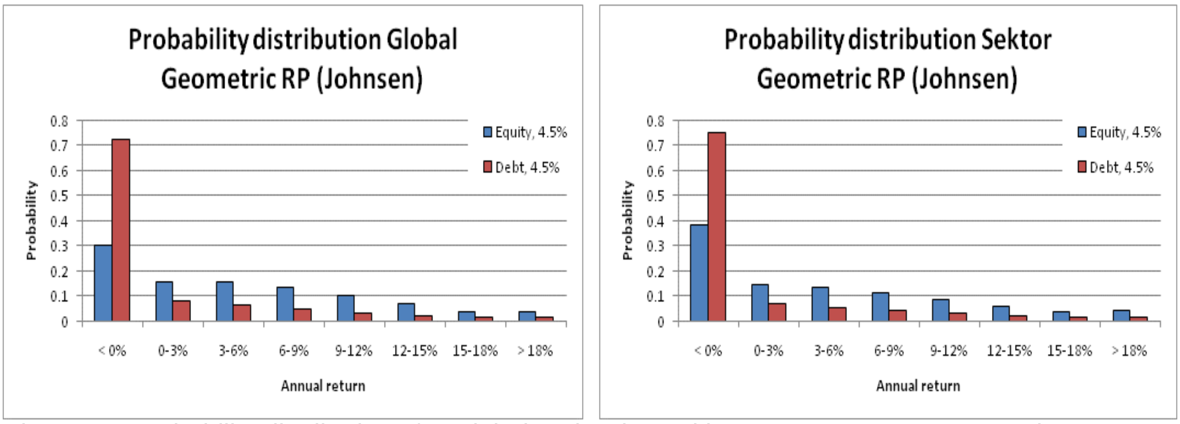



*Figure 12: Probability distributions for Global and Sektor with Johnsen's parameters and geometric RP*

It is also worth noting that the high volatility levels assumed by DnB NOR cause the corresponding geometric risk premiums to be lower than those chosen by Koekebakker and Zakamouline. The resulting expected returns from the simulation with the bank's parameters are also consistently smaller than in Koekebakker and Zakamouline's analysis. Although the high volatility level is "punishing" expected geometric return, it is also clearly contributing to the value of the product; a high standard deviation of the underlying portfolio cause the simulation to return many extreme observations in both tails of the distribution. However, since the option payoff is either positive or zero (Equation 2-3), only the positive extremes will significantly impact the average return on the option. For instance, the maximum option return achieved in the DnB NOR Sektor (geometric) simulation was 1596.22%, which implies an annual return of just over 59% (equity financed, 4.5% transaction fee). An equivalent negative draw would return 0%, and the positive draw will as such have a greater impact on the average option return.

Both the two products thus had negative expected returns from debt financing under the assumption of geometric risk premiums, but what were the results from the arithmetic simulations? Applying arithmetic risk premiums gives consistently lower estimates than Johnsen for Global, while the opposite is true for Sektor. The higher volatility levels assumed for Sektor has a much more positive impact on the product value than in the case of geometric risk premiums, since the arithmetic average return does not punish volatility. However, the estimates for Sektor are only slightly higher than those predicted by Johnsen, and are lower than the results from DnB NOR's model (which employs arithmetic risk premiums). The arithmetic simulations give the bank the benefit of high risk premiums, high volatility levels and high correlation (and as such no diversification effect reducing the volatility of the underlying portfolio); all which are factors that will positively influence the bank's estimate. Still, the expected return from a debt financed Global investment at 4.5% transaction fee is only 0.10% per annum, and the investor will lose money in nearly 2 out of 3 scenarios. The probability distributions with arithmetic risk premiums are shown in Figures 13 and 14.

In sum, the results from these simulations give grounds to doubt the bank's argument that debt financing could have been profitable for the customers. My analysis supports the conclusions from Koekebakker/Zakamouline and Johnsen, and also confirms Johnsen's predictions that the actual annual expected loss on the products are in the range of 3-5%[26].

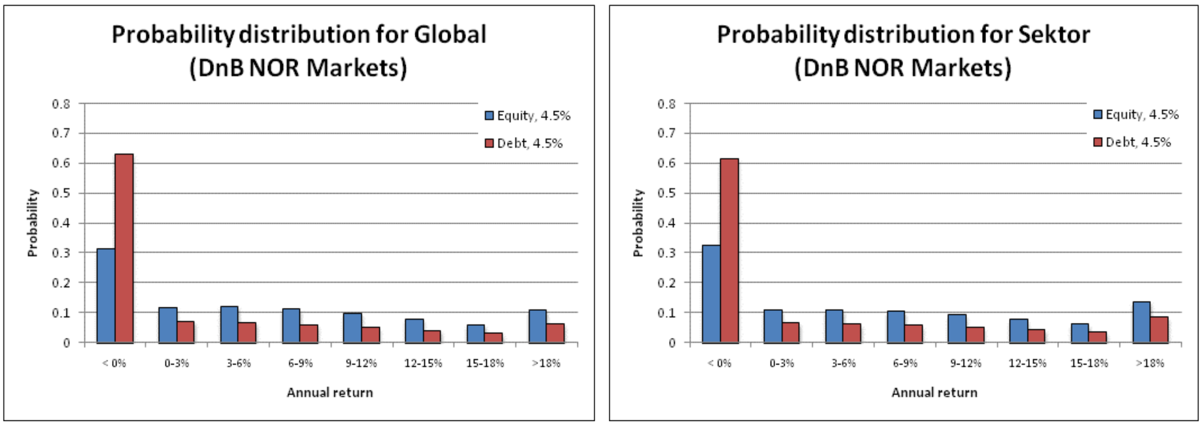



*Figure 13: Probability distribution for Global and Sektor with DnB NOR's parameters and arithmetic RP*

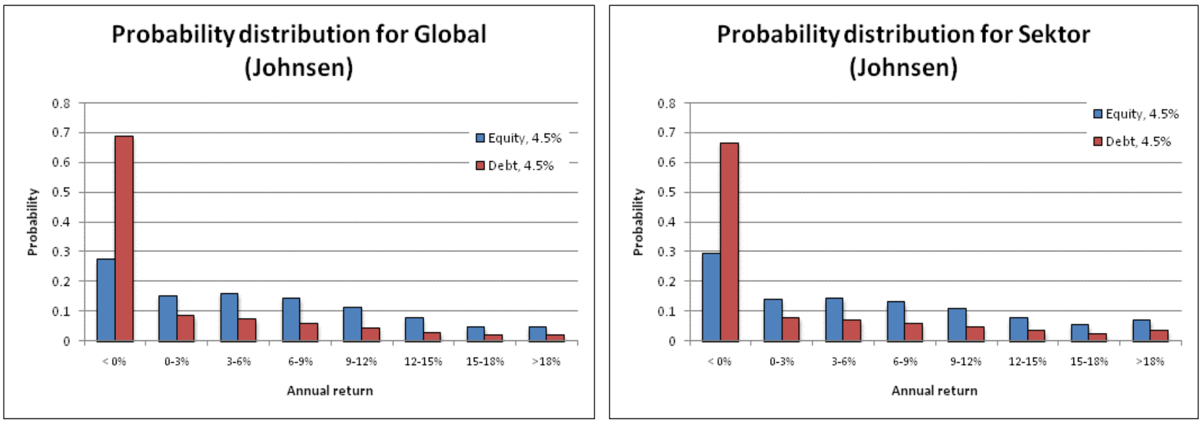



*Figure 14: Probability distribution for Global and Sektor with Johnsen's parameters and arithmetic RP*

[26] While Johnsen's model predict losses of 1-2.3% per annum, he estimate that the annual expected loss is actually 3-5%

## 4.5 Structured products as investment strategy: a note on debt financing

Why have structured products turned out to be such bad investment strategies for the average non-professional investor? Under certain conditions it is very rational for an investor to reduce his risk of loss by adding a derivative component to his portfolio, however it appears many of the products marketed in Norway were very costly; according to Kleven (2008, p. 2) “caused by the greed of some distributors”. More that 80 per cent of Norwegians have debt finance their investment in these products., and many experts (Bjerksund, Carlsen, & Stensland, 1999; Lindset, 2008; Johnsen, 2008; Solvær, Steinnes, & Stølen, 2006) have argued that such debt financing is particularly inappropriate for non-professional investors, which was confirmed by Kredittilsynet with the introduction of Circular 4/2008 in March last year. Let us briefly analyse why this is the case.

When an investor uses debt financing to finance 100% of the investment in the structured product, he in effect borrows money from the bank only to lend them back at a lower interest rate. In the case of DnB Global and Sektor, we have seen how the investor has borrowed to 8.51% p.a.[27] and received 6.77% p.a. on the capital protection component (zero-coupon bond) of the investment. Assume an investor borrows 104.5 to cover both the invested amount and the transaction costs. The bank will put 67.5 towards a zero-coupon bond, and 4.5 will cover the initial, visible transaction costs (see Figure 15). Johnsen (2008) estimates that the theoretical option premium including margin to the option seller is 26.8 for Global, which implies that the distributor, DnB NOR, received an extra margin of 5.7. I have created a diagram that shows how the borrowed amount can be divided into three different cash flows; one for the guaranteed component, one for the option, and one for the bank’s “service fees”. Notice that since the bank is charging a higher interest on the loan than what the investor is receiving from the bond, the guaranteed component will always have a negative contribution to the total payoff and thus expected return of the product. No matter what happens, the “guaranteed” component is a losing project, and the structured strategy would have a higher expected return if this *guaranteed loss* component was left out of the composite product and the investor invested in the option component directly. However, debt financing an option purchase can be described as a risky project at best; it involves

[27] Confirmed by DnB NOR in personal correspondence with Johnsen (2008)

gearing an already leveraged investment, and is both extremely risky and highly speculative. A 100% debt financed investment in DnB Global[28] can thus be characterised as a speculative, risky bet on the development in the EuroSTOXX, S&P and Nikkei indices coupled with a guaranteed loss component. This description certainly does not live up to the guaranteed product described in DnB's prospectus and it is doubtful whether such an exposition would have attracted many non-professional investors which would generally be seeking capital protection and other low-risk strategies.

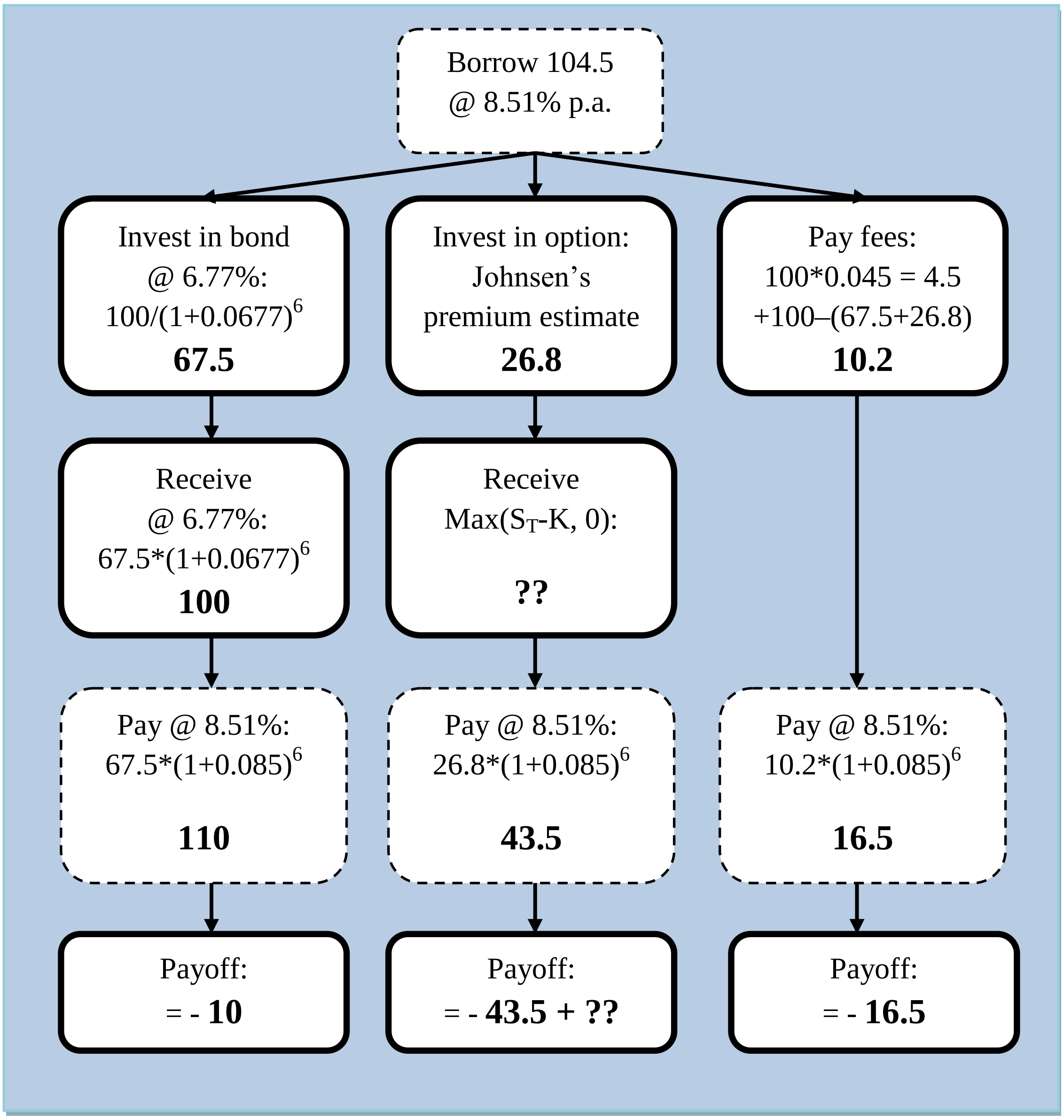



*Figure 15: DnB Global as investment strategy*

[28] The argument also applies to Sektor.

# 5. Analysing the Norwegian structured product market

In the previous chapters we have seen how structured products are created as well as how they can be valued, and we have applied this knowledge to a real world case. Using the Monte Carlo valuation technique we confirmed the results from previous analyses that the much debated products DnB Global and Sektor 2000/2006 have a negative expected return when the investments are debt financed. More than 80 per cent of investments in structured products have been financed by personal bank loans (SSB, 2009b), and Norwegian customers have lost approximately 14 billion kroner on these investments, according to estimations by Dine Penger (Stranden, 2009). The analysis in chapter 4 indicates that products of sub-standard quality have been distributed, and this gives rise to two important questions: why did the distributors sell such products? And why did customers buy them? In order to provide answers to these questions, we need to understand the underlying incentives that have driven behaviour on both the buyer and seller sides of the market for structured products. It is when we understand why this market existed in the first place that we also can address the question of whether the banks (and other suppliers) have taken advantage of information asymmetry in the sale of structured products.

## 5.1 The sellers and their incentives

While banks through their roles as intermediaries between lenders/savers and borrowers are important to the workings of the financial system and society in general, this does not suppress the fact that the primary goal of a banks' operations is to increase shareholder value by turning a profit[29]. Hence, the central question with respect to what incentives the banks had to sell structured products is whether these products were profitable. It is important to acknowledge that most banks have been extremely reluctant to release information to the public that could refute, or confirm, the massive criticism that has been directed towards the sale of (debt financed) structured products. Information such as cost structure, yearly profits and hedging expenses remain well protected business secrets. We can only speculate

[29] Although with the appearance of so-called ethical (social, alternative, civic, or sustainable) banks we have seen that not all banks adhere to this conventional goal, Cultura Bank in Norway is one example.

whether this is in order to avoid strategic information becoming available to competitors, or if such documentation would only trigger more criticism (Gjerde K. V., 2006a). It was in order to address some aspects of this obvious information gap that Kredittilsynet conducted their survey at the end of 2007. This report is the most comprehensive and credible source of information with respect to analysing supplier incentives and behaviour in the market for structured products, however it is important to keep in mind that it is based on self-disclosure and it is as such not completely impartial. Kredittilsynet (2008) could further report that the quality differences in the responses the banks gave in relation to income from structured products was substantial, however some useful information can still be found in this survey.

Firstly, DnB NOR reported that the income from structured products would normally approximate 2.5% of pre-tax profits. While this income might not be typical for other banks that have sold these products, it does give us an indication of the profit levels involved. The 2007 pre-tax profits for DnB NOR amounted to 15.4 billion NOK, which implies that the income from structured products according to Kredittilsynets' report would be in vicinity of 385 million NOK for 2007 (DnB NOR, 2008). Secondly, while the total income from these products did not necessarily account for a very large part of the banks' profits, more than 50 per cent of the banks stated that some of the income from the products were not directly related to the stated transaction fees and interest, but sprung from different product features such as product margin and structure margin; margins that for a long time customers were completely unaware of. The fact that these products posit possibilities for hiding fees have been thoroughly documented in the literature, and I have summarised the most relevant results in Table 9[30].

Thirdly, debt financing in relation to structured products has as we have seen been an extremely profitable combination for the banks. The interest spread for the customers in relation to the products Global and Sektor was for instance 1.74%. A margin of 1.74% when the default risk is limited to interest payments only is clearly a lucrative deal for the bank.

[30] The table only present results from a range of different analyses conducted on the actual value of these products. I have not evaluated the methods used to achieve the estimated price. The table assumes the issuing price of each product is 100.

| Study | Product | Estimated value |
|---|---|---|
| **Fossedal and Nagell (2000)** | DnB Teknologi/Farmasi 2000/2006 | 92.76 |
| **Johnsen (2008)** | DnB Global 2000/2006 | 94.31 |
| | DnB Sektor 2000/2006 | 94.25 |
| **Knutsen and Jensen (1999)** | Kreditkassen Global 1999/2005 | 88.57 |
| | Kreditkassen Global Risiko 1999/2005 | 84.65 |
| **Krogh (2002)** | DnB Japan 1997/2002 | 96.55 |
| | Nordea Europa 2002/2006 | 99.60 |
| | Postbanken BMA ’Best av’ 2002/2007 | 96.91 |
| | DnB BMA Global 2002/2005 | 98.10 |
| | Orkla Finans Podium 25 | 95.30 |
| **Lie, Lindset and Lund (2005)** | Garantibonus III | 96.40 |
| **Haugo (2007)** | DnB NOR Alternativ Energi III 2007/2009 | 99.39 |
| | Nordea Trippel Aksjer 2007/2009 | 96.33 |
| | DnB NOR Global Pluss 2007/2012 | 92.21 |
| **Husebø (2002)** | DnB Europa/USA 2002/2007 | 92.90 |
| | DnB Japan II 2000-2003 | 90.30 |
| | Sandnes Internasjonale Garanti 2001/2006 | 92.14 |
| **Loven and Garås (2008)** | Nordea Kraftobligasjon XIV 2007/2010 | 96.13 |
| | Orkla Finans Kraft II | 91.49 |
| | Nordea Aksjeverden 2008/2012 | 88.39 |
| | Handelsbanken Aksjeindeksobligasjon 3008A | 94.20 |
| **Solvær, Steinnes and Stølen (2005)** | DnB NOR Japan 2006/2009 | 96.86 |
| | Handelsbanken Europa/Japan 2005/2010 (low)[31] | 98.36 |
| | Handelsbanken Europa/Japan 2005/2010 (high) | 96.81 |
| | Fokus Bank USA/Japan 2004/2007 | 97.84 |
| **Sture (2001)** | DnB Global Titans 2001/2006 | 91.25 |
| **Wangen (2004)** | DnB NOR Faktor 150 | 98.87 |
| | Nordea Global Pluss India | 88.76 |
| | Fokus Allegro 18 | 97.03 |

*Table 9: Valuations of protected equity notes and market-linked CDs*

The fact that banks were earning money on these products is indisputable, even if it is difficult to estimate just how much they have earned. The profit potential provides a strong argument for why a bank should choose to distribute these products, but what considerations might have weighed against the decision? A negative public reaction stemming from banks providing sub-standard products holds the potential to damage the banks reputation and the possibility of losing customers. However, it seems likely that the banks perceived the cost of damaged reputation too small to offset the expected income from the products. We should also consider the possibility that the bankers responsible for creating and distributing these financial instruments did not expect the products to be exposed the way they have been

[31] When buying the Handelsbanken product the investor could choose between a risk averse (low) or more risk seeking alternative (high).

thanks to the global financial crisis that began in July 2007. In hindsight we have seen the products take a massive beating in Norwegian media and academia, which have caused a public relations disaster that the banks (and DnB NOR in particular) had not foreseen; and the costs of distributing sub-standard products have as such probably been a lot higher than the banks anticipated.

The profit-argument indicated that the banks should choose to sell these products, but why did moral considerations not prevent the banks from distributing them? Today, the connection between the bank and the customers is generally fairly transient, and not necessarily built on a long-term personal relationship. It seems that the nature of this relationship has caused many bankers to also view their obligations towards these customers on a more casual level, making it easier to act on the basis of profits rather than in accordance with the customer's best interest. An example of this is the choice of return factor in the Global and Sektor products. According to Johnsen (2008) it is particularly the employment of price averages, exclusion of dividends and significant hidden costs that considerably retard the return potential of these two products. These are design elements that the bank have actively decided to include when constructing the product. Johnsen (2008) calculated that by excluding hidden costs alone (i.e. only charging the transaction fees stated in the prospectus), the banks could have offered return factors of around 150% (1.5) for both products[32]. This would have significantly improved the customers' return prospects, even when the investments were debt financed.

The case of structured products has also opened for an increased focus on the conflict of interest faced by financial advisers employed by the bank. Because the adviser has significantly more knowledge about investment products than the customer it is possible for him/her to give recommendation that promotes their own interests on the expense of the client's. At the time when structured products first became popular there was no industry standard instigating how to appropriately deal with this conflict of interest, and the moral considerations were as such left up to the different institutions and the individual financial adviser. While it is difficult to determine whether the banks had official employee codes of ethics or codes of conduct 10 to 12 years ago, we can ascertain that such measures were insufficient in guiding employees through the ethical dilemmas they faced on a daily basis.

[32] Compared to the actual 105% for Global and 100% for Sektor.

Also, we also have reasons to believe that both individual institutions such as DnB NOR and the industry as a whole through the Norwegian Financial Services Association[33] (FNH) has realised that the ethical rules and guidelines that have existed so far were inadequate. DnB NOR informs for instance on their investor relations web site that a larger, company-wide program focusing on ethics was introduced in 2009 (DnB NOR, 2009). Moreover, FNH and its member organisations have recently adapted an authorisation program for financial advisers (Autorisasjonsordningen for Finansielle Rådgivere), which has a strong focus on how ethical dilemmas can best be managed; the FNH has even developed a guide to ethics as part of the curriculum for the program (Kvalnes, 2009). These recent measures is a strong signal that the banks and other financial institutions recognise that the focus on moral principles and beliefs have not been strong enough. In the case of structured products it appears that we had a situation where profit margins took precedence over ethics.

There is also another plausible explanation why financial advisers in particular did not question the morality of offering debt financing in relation to structured products: If these advisers did not truly understand the characteristics of the products they were selling, and in fact had no better comprehension of the risks involved and return potential than the investor, then they might have actually believed that they were acting in the best interest of their customers. Financial advisers have been strongly criticised for not having sufficient knowledge and understanding of structured products (Hegle, 2009; Gjerde K. V., 2006b). Kredittilsynet could report that the majority of banks have had internal training programs for their advisers in relation to structured products, which would culminate into a final exam or test. Approximately 30 per cent of the banks did not have a test which was directly linked to these products. Also, nearly 50 per cent of the banks experienced that advisers did not pass this exam; most banks would in this case suspend the person's right to sell the products until he or she re-sat and passed the exam; one bank would limit the amount of tests allowed to three before the candidate would be reassigned; and another stated that they imposed no consequences what so ever. The industry now seems to be taking the problem of incompetent financial advisers more seriously, with the establishment of the authorisation system for financial advisers in Norway (Autorisasjonsordningen for Finasielle Rådgivere,

[33] FNH represents banks, insurance companies, finance companies, management companies for securities funds, investment firms and financial conglomerates in Norway.

2009). Also, regulatory authorities have signalled that they will enforce stricter and more frequent controls of the quality of financial advice in the future (Finansdepartementet, 2009).

## 5.2 The buyers and their incentives

In the previous section we discussed why the banks chose to sell products that were obviously not designed in the best interest of their customers, and in this section we will ask how they managed to get away with it for so long: Why did customers continue to buy these products? Structured products were originally created for and introduced to the professional segment of the retail market, but is it really this group of investors that have been buying the products? Almklov, Tørum, & Skjæveland (2006) found that approximately 90 per cent of the debt financed structured products was held by non-professional investors, and it is reasonable to assume that these investors are also behind a large majority of the outstanding investments in equity financed products. Since professional investor participation has been low in the market (Sparre M. R., 2009a), and because their informational position relative to the bank is completely different to that of non-professional investors, I will here focus on the last group only.

The banks have been very reluctant to share any information with respect to what types of customer buy structured products. While there is no reliable information gathered on the specific demographics of the segment, we know from media reports that it is the Average Joe that has invested in this product. Although we do not have specific information on the risk tolerance and preferences of investors in structured products, we do have such information on Norwegian non-professional investors in general. According to a recent survey conducted by Forbrukerrådet, only 7% answer that they are willing to accept a larger amount of risk on their investments in order to achieve a return over the risk-free rate (see Figure 166) (Forbrukerrådet, 2009a). Two out of three Norwegians will accept small level of risk or no risk what so ever, which imply that the general non-professional investor is fairly risk-averse.

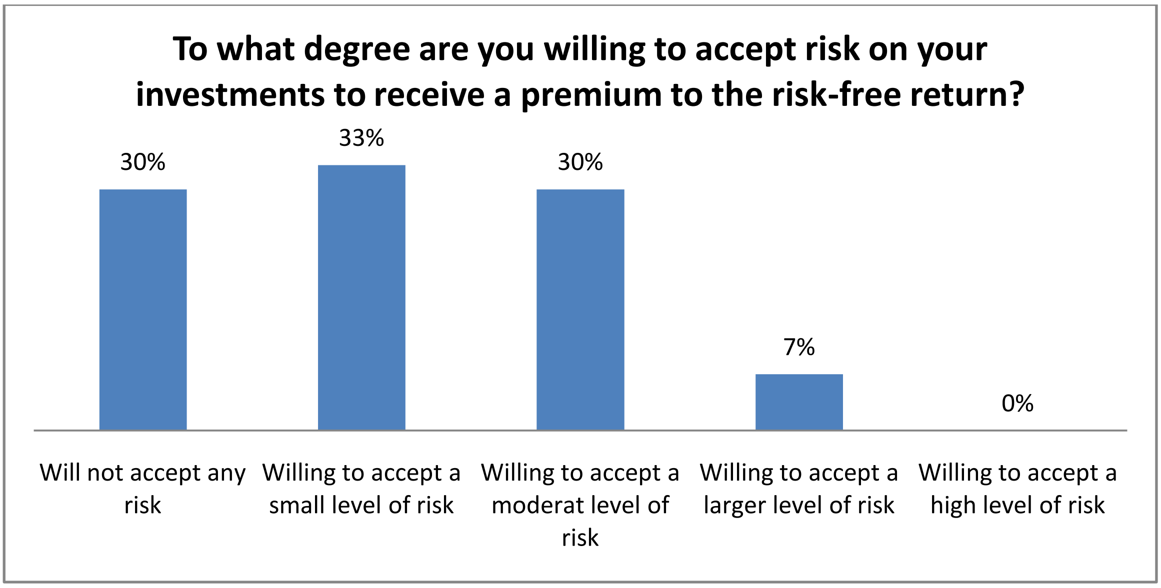



*Figure 16: Degree of risk tolerance non-professional investors (Forbrukerrådet, 2009a, p. 8)*

This finding was not controversial compared to previous surveys; however Forbrukerrådet was surprised to find that the risk profile was quite similar when grouping the participants according to the actual investments they had conducted; see Figure 177.

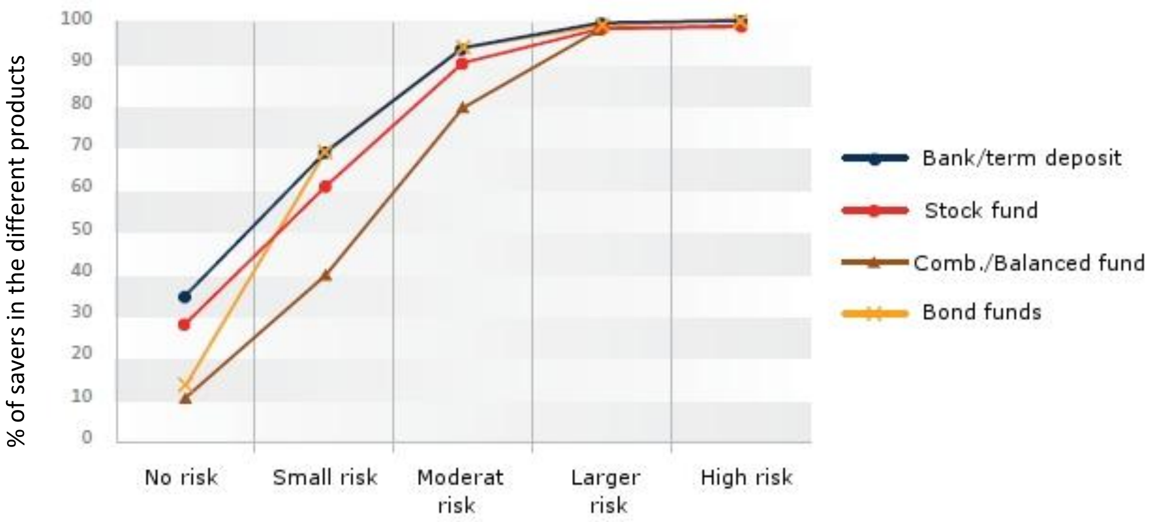



*Figure 17: Accumulated risk acceptance over four product types (Forbrukerrådet, 2009a, p. 8)*

It is quite a paradox that a remarkable 61% of investors that save in stock market funds, which are moderate to high risk products, have little or no acceptance of risk on their savings (Forbrukerrådet, 2009a). It is clear that a large fraction of the non-professional investors do not understand the risk factors of a common product such as a managed stock fund. The survey further shows that nearly half of the investors placed their money in stock funds based on recommendations from an investment adviser at the bank or other financial institution, which implies that many advisers fail to ensure that the investor fully understands the risk factors of the investment (Forbrukerrådet, 2009a). The survey also asked what time horizon the investors had with respect to the savings and the result here was very varied. Also, more than 50% of participants stated that it was important or very important for them to have access to the savings within the investment period. In summary we can infer the following about the average non-professional, Norwegian investor:

- He is very risk averse, and will only accept a small amount of risk on his investments;
- He has a time horizon that reflects individual needs and aspirations;
- He needs to be able to access at least parts of the investment in the investment period;
- He has a limited understanding of the basic relationships of finance.

### 5.2.1 Irrational preferences

The marketing brochures for these products touted capital protection coupled with market exposure; that is, a potential for high returns with virtually no risk of losing money. Although it is relatively obvious why this is attractive to the non-professional investor, it can also be explained using Kahneman and Tversky’s (1979) prospect theory. While traditional finance use the variance as a risk measure and suggest that individuals weigh both positive and negative returns equally, prospect theory claims that individual risk preferences are not determined solely by deviations from the mean but depend significantly on gains and losses with respect to a certain reference point (Hens & Bachmann, 2008). The concept most relevant to our discussion of structured product is the pseudo-certainty effect, which refers to people’s contradictory attitudes towards risks involving gains and losses. Tversky and Kahneman (1981) found a systematic reversal of investor’s preferences by variations in the framing of contingencies and/or outcomes, and showed that choices involving gains are often risk averse whereas choices involving losses are often risk taking. While it involves a minor deviation from our present discussion, let us briefly look at one of the tests performed by the two psychologists, which clearly demonstrates the idea of this framing effect.

Presented with a scenario where the government was preparing for an outbreak of an unusual Asian disease expecting to kill 600 people, participants were asked to choose between two alternative programs to combat the disease. If program A was adopted, 200 people would be saved, whereas if program B was adopted there was a 1/3 probability that 600 people would be saved, and 2/3 probability that no people would be saved. In this scenario, 72% (28%) of participants preferred alternative A (B). A second group of people were given the exact same scenario, but with a different formulation of the alternative programs: under treatment strategy C, 400 people would die, and in program D there was a 1/3 probability that nobody would die, and 2/3 probability that 600 would die. The alternatives for the two scenarios are effectively identical, the only difference is that program A and B describe the outcome in terms of lives saved, whereas C and D describe the lives lost. Surprisingly, this change is accompanied by a pronounced shift from risk aversion to risk taking, with 78% of participants preferring program C to program D. Kahneman and Tversky (1991) further demonstrates that this risk aversion when evaluating gains is caused by people's tendency to strongly prefer avoiding losses to acquiring gains[34]; a behavioural bias referred to as *loss aversion*. The banks have clearly played on this tendency of irrational preferences and framing effects in the construction, marketing and sale of structured products. These products were first introduced to the Norwegian market at a time where a lot of investors had lost money by saving in stock market and other types of mutual funds. In a time where the market was experiencing increased loss aversion, the main marketing point of these products was that the customer is guaranteed loss-avoidance; he is "guaranteed" to receive the invested capital at expiration. The investments were as such packaged and sold by exploiting loss aversion, a well known form of irrationality. The banks cleverly focused on the loss protection component, and evaded correctly informing customers about inherent risks, especially when it came to the use of debt financing. Unfortunately, what customers realised far too late was that no such guarantee or loss protection exist once you debt finance these types of structured products (Ormseth, 2009).

Irrational preferences provide one explanation for why structured products were so popular among non-professional investors. The other significant factor that has played an important role is information asymmetry, specifically the impact of asymmetric information in a

[34] In fact, some studies suggest that psychologically speaking, losses are twice as powerful as gains

situation based on trust and confidence. This aspect is closely related to the well-known market for lemons problem, and we will discuss this issue next.

### 5.2.2 Akerlof's Market for Lemons

The Market for Lemons problem was first presented in George Akerlof's seminal paper, and is a problem that can occur in any market where there are buyers and seller of products (Høgsand, 2008). Akerlof (1970) argues that in markets where buyers use some market statistic to judge the quality of prospective purchases there are incentives for sellers to market poor quality merchandise as higher-quality ones. While Akerlof developed his argument using the market for used cars as an example, the theory can just as well be applied to financial markets in general and structured products in particular. The theory is very helpful in explaining why non-professional investors kept buying complex and unprofitable products.

A situation of asymmetric information exists when one party to a transaction has more or better information than the other (Dixit & Skeath, 2004). This lack of information or power imbalance creates problems on two fronts; adverse selection before the transaction is entered into and moral hazard[35] after (Mishkin, 2007). The way the adverse selection problem interferes with the efficient functioning of a market is called the "lemons problem", referring to the problems caused by lemons in the used-cars market. This problem implies that potential buyers are unable to assess whether a particular used car is a good car that will run well (a peach), or a lemon that will continually give them grief. The buyer will thus only be willing to pay a price that reflects the average quality of the cars in the market (Mishkin, 2007). In contrast, the owner of the car is more likely to know whether the car is a peach or a lemon. The owner of a lemon is more than happy to sell the car, since the average price the buyer is willing to pay is higher than the actual value of the lemon. Conversely, owners of peaches know that their cars are undervalued at the price buyer is willing to pay, and may as such not want to sell it. The result of this adverse selection is that few good used cars will come to the market (Akerlof, 1970; Mishkin, 2007).

[35] Moral hazard refers to "the risk (hazard) that the borrower might engage in activities that are undesirable (immoral) from the lender's point of view, because they make it less likely that the loan will be repaid" (Mishkin, 2007, p. 38), and is as such not particularly relevant in this context.

### 5.2.3 Are structured products lemons?

We can see how the market for lemons problem might be an attractive explanation to the massive popularity and later down-fall of the structure products market. According to Akerlof (1970), the following characteristics will produce a lemon's market: the presence of asymmetric information; the existence of incentives for sellers to pass of low quality products as higher quality products; the lack of credible disclosure technology on behalf of the sellers; a continuum of product qualities; and a deficiency of effective public quality assurances such as warranties and regulation.

Distributors and sellers (financial advisers) of structured products have clearly had more and better information than the buyers, and the presence of asymmetric information is as such indisputable, although it appears that many investors have been unaware of its existence (Høgsand, 2008). Let us consider low quality products to be products that contain large hidden margins/profits to the sellers and/or have a limited return potential (such as many debt-financed products). If the distributors can pass of these products as higher quality products they will earn higher margins, which is a strong incentive endorsing such behaviour. The prospectuses used to promote structured products have proven to be deficient at best, and the products themselves are complex and difficult for the potential buyer to evaluate. Also, even people with sufficient expertise disagree on how to price the option component of structured products, and the banks have as such had no credible means to disclose the true quality of their products. In previous discussions we have seen that the structured product market both comprise a vast range of product (and seller) qualities, and until early 2008 the regulatory presence was inadequate.

Akerlof (1970) predicts that the presence of people in the market who are willing to offer inferior goods will tend to drive the market out of existence. In the case of structured products, the massive criticism in media and the eventual regulatory action have caused the market to more or less evaporate; although we have seen that banks are trying to replicate the protected equity note/market-linked CD success with other structured innovations such as warrants. Most banks have put a complete halt to the sale of structured products to non-professional investors, and while it is good that this group of investors are now better protected against buying lemons, it also implies that they are more or less unable to buy peaches. The costs associated with bad products is thus not only the amounts lost by cheated customers, but also the losses incurred from driving legitimate business out of existence (Akerlof, 1970).

The factors described above indicate that the structured product market somewhat resembles a market for lemons, or at least that the density of lemons is high. However there is one aspect that differs greatly from a traditional lemons market, namely that the structured product market has experienced information asymmetries in two different dimensions: one is with respect to quality, and the other is due to the fact that customers were not aware of the fact that information asymmetry existed in the first place. A pure market for lemons is just a big a problem for sellers as it is for buyers, but this is clearly not the case when it comes to structured products. The main issue here is that most buyers did not consider information asymmetries and were completely unaware of the prospect that many products could very well be lemons; instead they trusted the advise and recommendation provided by the bank employees. An important key for understanding the problems in this market is to recognise the market strength of the banks. The Head of Securities Institutions Selection at Kredittilsynet Eystein Kleven commented in a presentation to the Structured Products Europe conference that one of the largest problems with respect to structured products are the circumstances in which these products have been sold (Kleven, 2008). Products have been constructed in a complex and complicated manner, and it has been nearly impossible for common investors to properly evaluate the expected return and understand the risks involved. This lack of transparency coupled with the fact that products "have been sold on the investor's confidence in the distributors as investment advisers" have given the distributors an immense and unique power (p. 1). This power disparity has played out in the interactions with both customers and with the banks' own suppliers; because many producers compete for delivery of the products or option components to the distributor, the distributors have had incitements to choose the producer that will grant the largest rebate or discount on the option premium.

The distributors held a strong position with respect to their own suppliers, but what has characterised the relationship with customers? The sale of structured products has for the most part been conducted by so-called financial advisers stationed at the bank. Customers have in meetings with these bank employees believed that they were receiving *advice* and sound *recommendations*, and in many cases failed to realise that they were subject to *sales*. Many investors had limited knowledge of financial markets and theory, and were as such completely reliant on the financial adviser; they both expected and trusted that any recommendations resulting from these meetings were inherently in their best interest. A common analogy for the adviser/investor situation is the doctor/patient case. The doctor has a medical education and is in a far superior informational position as compared to his patient. Yet the patient would expect that the diagnosis reached by the doctor is correct and based on the patient's symptoms, as opposed to whatever diagnosis provides the largest profit margin for the hospital. Now, the doctor/patient context is of course heavily regulated, and it is as such a situation of "regulated trust". In the case of financial adviser and client it appears that when the supervisory body failed to regulate the relationship, the trust was completely misplaced.

In summary we have a situation where two factors in particular explain why these products were so popular among non-professional investors. Firstly, the irrationality of preferences which was actively used by the banks in marketing materials, design and sale of structured products. Secondly, the misplaced trust in a situation of information asymmetry. The last question I want to ask in this chapter is whether we have reasons to believe that the banks have consciously taken advantage of their superior informational position in the production and distribution of these products? In order to answer this question we must first ask whether it is likely that the distributors realised that the average non-professional investors would not truly understand the products. We have seen that structured products are relatively complex and very difficult to evaluate, and it is reasonable to assume that an investor must have a more than basic comprehension of financial theory and markets in order to accurately evaluate such products - and this notion must also have been obvious to DnB NOR and other distributors of structured products. Furthermore, through their daily dealings with this particular investor group it should be expected that advisers/sellers can assess the financial knowledge and sophistication of their customers, in fact this expectation has been formalised through the adaption of the MiFID from November 2007 (Høgsand, 2008). The answer to our question then is clearly yes, the banks must have realised that the average customer would not comprehend the likely consequences from debt financing structured products.

When we consider this issue in conjunction with the fact that

- the banks have been selling structured products with hidden margins/costs and in likely negative expected returns;

- that buyer behaviour has been driven by the desire for ‘low risk’ and ‘stock market gains’ – the notion that you can have your cake and eat it too, overcoming the conventional laws of finance; and
- that the products have not been particularly popular among professional investors, more than likely because many of these realise that in an efficient market you cannot achieve high returns without carrying risk

it is rational to conclude that the banks have in fact taken advantage of their superior informational position, and as such misused their customers’ trust and confidence, in the sale of structured products.

# 6. Conclusions and final comments

This paper has asked whether Norwegian banks have taken advantage of a superior informational position in the sale of structured products. In chapters 2 and 3 I presented a framework for understanding the different components of structured products as well as the market for such products in Norway. Two protected equity notes, DnB Global and Sektor 2000/2006, were analysed in chapter 4, and I concluded that the expected negative return when fully debt financed was negative for both products. The results from this analysis indicates that Norwegian banks have been selling sub-standard products, and in chapter 5 we asked why these products were marketed in the first place, and how they became so popular among non-professional investors. The conclusion from our discussion is that Norwegian banks have taken advantage of information asymmetries when selling structured products, and have as such profited because customers did not fully understand the true value and the risk characteristics of these products. A central question the Courts must decide is who is responsible for what happened in this market: the customers themselves; the sellers/distributors/producers; regulators; or a combination of these three? It is possible to argue that the customers should and must carry at least some of the responsibility. Claims that Norwegian non-professional investors are fairly naive and easily deceived when it comes to investments and financial decision making fuels a discussion of whether the only way for these investors to learn how to protect their finances is the hard way (Dn.no, 2009; Sparre M. R., 2009b). However, the analysis from this paper suggests that banks through the use of financial advisers have a strong and irrevocable responsibility.

The sale of structured products has predominantly been conducted by financial advisers stationed at the bank, but also in some cases through agents and other providers. In the survey conducted by Kredittilsynet, the banks were asked to account for how they separate between the areas of sales and advising; the report concluded that this line of separation was unclear (Kredittilsynet, 2008). Just over 50 per cent of the respondents claim that they separate between advising and selling structured products, however many would argue that it is questionable how clearly this distinction have been communicated to the customers (Tørring, 2009; Sparre M. , 2008; Bergo, 2007; Flesland R. S., 2009; Berge & Forseth, 2009). Also, more than half of the respondents to Kredittilsynet’s survey admitted that their sellers/advisers receive financial rewards from selling structured products, and 20% of the banks provided additional rewards when these products were debt financed, including DnB

NOR (Kredittilsynet, 2008). Hence, the financial incentive to sell (debt financed) structured products was strong, and we have previously discussed how moral objections seems to have had little influence over this decision. It has been proposed that a seller should be unable to use the title ‘financial adviser’ when he receives commission, bonuses or other financial incentives from recommending or selling products (Finansdepartementet, 2009), and I believe such an enforcement is highly necessary. For what factors must necessarily be present in order to call it advising, and not selling? Providing sound financial advice entails a thorough evaluation of the investor with respect to at least the following dimensions; the investor’s experience, his loss aversion, risk preferences, financial goals, liquidity needs and time frame. Many would also argue that investment universe recommended by an adviser cannot be limited to one bank’s products only, i.e. that the adviser must be completely independent. The ‘financial advisers’ employed by banks are clearly not independent, and are according to Forbrukerrådet’s survey in many cases also unable to accurately evaluate the needs of their customers (Forbrukerrådet, 2009a). The investment in structured products has as such generally not been a result of financial advising, but a consequence of good salesmanship. Norwegian non-professional investors have (blindly) trusted the recommendations received from what are, in essence, glorified sellers, without considering the fact that these financial advisers might not solely be acting in their clients’ best interests. The recommendation of structured products as an investment strategy is as such not sound advice, but a pure sales pitch, and constitutes evidence that intermediaries, who at the same time acting as advisers and distributors, have been able to misuse trust and confidence in the market.

The problem of asymmetric information in the structured product market demonstrates why the financial industry is among the most regulated sectors of an economy. Yet we have seen that the appropriate Norwegian supervisory bodies were relatively slow to react to the conditions in the market, particularly with respect to controlling the role of the seller/adviser (Holst I. R., 2008b). It was the business press that first blew the whistle on these questionable practices[36], and it was only after significant media pressure that authorities took necessary action. However, since first entering the game it seems that Kredittilsynet is giving priority to monitoring how banks and investment firms practice the new, stricter

[36] Particularly Dine Penger and editor in chief Tom Staavi (Tørrvold, 2009)

requirements concerning advisory services and the distribution of structured products (Kleven, 2008). Through a series of on-site inspections at relatively newly established investment firms the regulators revealed a series of infringements regarding the duties towards customers pursuant to the Securities Trading Act, some of which led to a licence withdrawal (Glitnir Privatøkonomi and Caveo are examples of this) (Flesland S. , 2009; Holst I. , 2008a).

While the development in the market for structured products makes a strong case for a significant regulatory presence, it is important to keep in mind that the regulators are likely to continuously be one step behind the industry. A consequence of financial innovation is that the regulation of financial markets will always be reactive as opposed to proactive, since the government cannot regulate products that have yet to be created. Thus, the regulators have included a provision concerning appropriate business conduct in the Securities Trading Act (chapter 10) as one of the factors ensuring investor protection and a minimum standard when providing investment advice. Because financial institutions are given exclusive rights to carry out investment services they are in a position that "implies special duties to care for their clients" (Kleven, 2008), and customers are as such entitled to receive financial advice that suit their individual needs and protects their interests. This provision implies that it cannot solely be a governmental responsibility to ensure prudent business practices and prevent misconduct; this also constitutes an ethical responsibility to the banks and other corporations in the industry. The gap that is created when governmental authority is incapable of immediate action must be closed through socially responsible corporate practices.

It would be an interesting topic for future master theses to investigate how financial advisers and institutions practice the new regulatory requirements following MiFID and other amendments to the Securities Trading Act. Another topic could be an analysis of the quality and soundness of investment advice given by financial advisers employed by banks.

# 7. References


Aasnes, H., & Semmen, K. (1997). Markedet for "strukturerte spareprodukter": Same shit, new wrapping? *Derivatet , 4* (1), 11-14.

Akerlof, G. (1970). The market for lemons: quality uncertainty and the market mechanism. *The Quarterly Journal of Economics , 84* (3), 488-500.

Almklov, G., Tørum, E., & Skjæveland, M. (2006). Utviklingstrekk i kredittmarkedet - nye utlånstyper og omfanget av fastrentelån i Norge. *Penger og Kreditt , 34* (3), 184-193.

Andersson, J. E. (2009). *Spareproduktene havner i retten.* Retrieved February 14, 2009, from Forbrukerrådet : http://forbrukerportalen.no/Artikler/2009/spareproduktene_havner_i_retten

Autorisasjonsordningen for Finasielle Rådgivere. (2009). *Felles autorisasjon for finansielle rådgivere*. Retrieved 5 25, 2009, from Autorisasjonsordningen for Finasielle Rådgivere: http://www.autorisasjonsordningen.no/

Axelsen, K. A., & Rakkestad, K. J. (1999). Garanterte investeringsprodukter. *Penger og Kreditt , 28* (1), 74-82.

Bankklagenemnda. (2009-005). *Andeler i hedgefond solgt til 88-åring*. Retrieved March 17, 2009, from Bankklagenemda - klagenemnd for bank, finans og verdipapirfond: http://www.bankklagenemnda.no/php/uttalelser.php?action=vis&uid=918

Bankklagenemnda. (2009-019). *Lånefinansiert plassering i BMA knyttet opp mot hedgefondindeks, solgt til 20-årig uformuende mann gjennom finansagent – utilrådelig plassering?* Retrieved March 17, 2009, from Bankklagenemnda - klagenemnd for bank, forsikring og verdipapirfond: http://www.bankklagenemnda.no/php/uttalelser.php?action=vis&uid=932

Bankklagenemnda. (2009-001). *Lånefinansierte aksjeindeksobligasjoner – forventet negativ avkastning?* Retrieved March 18, 2009, from Bankklagenemnda - klagenemnd for bank, forsikring og verdipapirfond: http://www.bankklagenemnda.no/php/uttalelser.php?action=vis&uid=914

Benninga, S. (2008). *Financial Modelling* (3rd ed. ed.). Cambridge, Massachusetts: The MIT Press.

Berge, L., & Forseth, U. (2009). *Råsalg i finansnæringen?* Retrieved 5 13, 2009, from Adresseavisen: http://www.adressa.no/meninger/article1323934.ece

Bergo, A. (2007). Investeringsrådgivning. *Praktisk Økonomi og Finans , 24* (4), 81-90.

Bjerksund, P. (2008). Hvordan bankene har påført sine kunder skjulte kostnader med lånefinansierte garanterte spareprodukter. *Praktisk Økonomi og Finans , 25* (2), 81-85.

Bjerksund, P., Carlsen, F., & Stensland, G. (1999). Aksjeindekserte obligasjoner - både i pose og sekk? *Praktisk Økonomi og Finans , 16* (2), 74-82.

Bjørndal, B., & Fadnes, O.-M. (2008). *Setter Acta under lupen*. Retrieved 3 15, 2009, from Dagens Næringsliv: http://www.dn.no/forsiden/borsMarked/article1432036.ece

Black, F., & Scholes, M. (1973). The pricing of options and corporate liabilities. *Journal of Political Economy , 81*, 637-659.

Bodie, Z., Kane, A., & Marcus, A. J. (2005). *Investments* (6th ed.). New York: McGraw-Hill/Irwin.

Bøe, G. M. (2007). *Analyse av strukturerte spareprodukter: Et kinderegg for banknæringen?* Norges Handelshøyskole: Masterutredning i fordypningsområdet Finansiell økonomi.

Boyle, P. P. (1977). Options: A Monte Carlo approach. *Journal of Financial Economics , 4,* 323-338.

Boyle, P., Broadie, M., & Glasserman, P. (1997). Monte Carlo methods for security pricing. *Journal of Economic Dynamics and Control , 21* (8-9), 1267-1321.

Brattlie, N. G., Kleiven, A., & Jordheim, S. R. (2007). Realisert avkastning på strukturerte spareprodukter - En kritikk av anvendt metode. *Praktisk Økonomi og Finans , 23* (4), 107-116.

Cox, D., & Miller, H. (1965). *The theory of stochastic processes.* London: Chapman and Hall.

Cox, J., & Ross, S. A. (1976). The valuations of options for alternative stochastic processes. *Journal of Financial Economics , 3* (1-2), 145-166.

Cox, J., Ross, S., & Rubinstein, M. (1979). Option pricing: A simplified approach. *Journal of Financial Economics , 7* (3), 229-263.

Damodaran, A. (2009). *S&P Earnings: 1960-Current*. Retrieved May 18, 2009, from Damodaran Online: http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/spearn.htm

Dimson, E., Marsh, P., & Staunton, M. (2000). *The Millennium book - A century of investment returns.* London Business School: ABN Amro.

Dixit, A., & Skeath, S. (2004). *Games of strategy* (2nd Edition ed.). New York: W.W. Norton & Company.

Dn.no. (2009). *-Nordmenn er spesielt lettlurte.* Retrieved 5 4, 2009, from Dagens Næringsliv: http://www.dn.no/forsiden/politikkSamfunn/article1661937.ece

DnB Markets. (2000a). *DnB Aksjeindeksobligasjon - Global 2000/2006.* Retrieved February 1, 2009, from DnB NOR Bank ASA: https://www.dnbnor.no/portalfront/nedlast/no/markets/prospekt/0010067747_DnB_Global_0006_tegn.pdf

DnB Markets. (2000b). *DnB Aksjeindeksobligasjon - Sektor 2000/2006.* Retrieved February 1, 2009, from DnB NOR Bank ASA: https://www.dnbnor.no/portalfront/nedlast/no/markets/prospekt/0010067739_DnB_Sektor_0006_tegn.pdf

DnB NOR. (2008). *DnB NOR Bank ASA: Årsrapport 2007.* Retrieved June 10, 2009, from DnB NOR Investor Relations: https://www.dnbnor.com/portalfront/nor_com/nedlast/no/2007/resultater/aarsrapport_dnbnor_bank_2007_080408.pdf

DnB NOR. (2009). *Fremhever etikk*. Retrieved June 15, 2009, from DnBNOR.com - Informasjon for investorer: https://www.dnbnor.com/om_konsernet/etikkregler/desketikkregler.html

Døskeland, T. (2009, February 12). Ingen å stole på. *Dagens Næringsliv* , p. 29.

Fama, E. (1970). Efficient capital markets: A review of theory and empirical work. *Journal of Finance , 25* (2), 383-417.

Fama, E. F. (1965). The behaviour of stock prices. *Journal of Business , 38* (1), 34-105.

Finansdepartementet. (2009). *Kristin Halvorsen's tale til Forbrukerrådets nasjonale rundbordskonferanse om bankenes samfunnsansvar.* Retrieved April 29, 2009, from Finansdepartementet: http://www.regjeringen.no/nb/dep/fin/dep/finansministeren/taler_artikler/2009/bankenes-samfunnsansvar.html?id=557785

Flesland, R. S. (2009). *Kronikk: Selger eller rådgiver?* Retrieved 4 3, 2009, from Forbrukerportalen: http://forbrukerportalen.no/kronikk/selger_eller_radgiver

Flesland, S. (2009). *Finansrådgivere mister konsesjon.* Retrieved June 17, 2009, from NA24.no: http://arkiv.na24.no/Nyhet/345785/Finansr%C3%A5dgivere+mister+konsesjonen.html

Forbrukerrådet. (2009a). *Forbrukerrådets forslag til ryddepakke i sparemarkedet - undersøkelse av finansiell rådgivning.* Retrieved March 23, 2009, from Forbrukerportalen: http://forbrukerportalen.no/Artikler/2009/Bankenes_sparerad_star_til_stryk

Forbrukerrådet. (2009b). *Spareproduktene havner i retten.* Retrieved March 25, 2009, from Forbrukerportalen: http://forbrukerportalen.no/Artikler/2009/spareproduktene_havner_i_retten

Fossedal, S., & Nagell, A. (2000). *Vurdering av en aksjeindeksobligasjon - teoretiske og praktiske metoder.* Norges Handelshøyskole: Masterutredning i fordypningsområdet finansiering og finansiell økonomi.

Fouque, J.-P., & Han, C.-H. (2004). Variance reduction for Monte Carlo methods to evaluate option prices under multi-factor stochastic volatility models. *Quantitative Finance , 4* (5), 597-606.

Gjerde, K. V. (2006a). *Beskylder bankene for uærlighet.* Retrieved February 12, 2009, from Dagens Næringsliv: http://www.dn.no/forsiden/borsMarked/article714108.ece

Gjerde, K. V. (2006b). -*Uetiske og inkompetente råselgere*. Retrieved 4 20, 2009, from Dagens Næringsliv: http://www.adressa.no/meninger/article1323934.ece

Glasserman, P. (2003). *Monte Carlo methods in financial engineering.* New York: Springer-Verlag.

Gran, B., Hegle, H., & Mikalsen, B. E. (2009, March 9). Ny bank avviser Bankklagenemda. *Dagens Næringsliv* , 10.

Haugo, T. (2007). *Aksjeindeksobligasjoner - fair priset for kunden?* Norges Handelshøyskole: Siviløkonomutredning i HAS.

Hegle, H. (2009). *Håndverker ble tilbudt jobb som finansrådgiver*. Retrieved 2 12, 2009, from Dagens Næringsliv: http://www.dn.no/privatokonomi/article1604495.ece

Hens, T., & Bachmann, K. (2008). *Behavioral finance for private banking.* Chichester: Wiley.

Høgsand, M. (2008). *Garanterte spareprodukter - nødvendigheten av en produktstandard.* Norges Handelshøyskole: Siviløkonomutredning.

Holst, I. (2008a). *Mister konsesjon.* Retrieved June 17, 2009, from DinSide.no: http://www.dinside.no/520012/mister-konsesjon

Holst, I. R. (2008b). *Slutt på spareprodukter med negativ avkastning.* Retrieved 6 11, 2009, from Din Side: http://www.dinside.no/509158/slutt-paa-spareprodukter-med-negativ-avkastning

Hull, J. C. (2005). *Fundamentals of Futures and Options Markets* (5th ed.). New Jersey: Pearson Education, Inc.

Hull, J. C. (2006). *Options, futures and other derivatives* (6th edition ed.). New Jersey: Prentice Hall.

Husebø, S. B. (2002). *Teoretisk og numerisk verdsettelse av aksjeindeksobligasjoner.* Norges Handelshøyskole: Studentutredning HAS.

Johnsen, T. (2008). *Forventet avkastning på DnB Global 2000/2006 og DnB Sektor 2000/2006*. Retrieved January 23, 2009, from Forbrukerportalen: http://forbrukerportalen.no/filearchive/rapport_strukturerte_produkter.pdf

Joy, C., Boyle, P. P., & Tan, K. S. (1996). Quasi-Monte Carlo Methods in Numerical Finance. *Management Science , 42* (6), 926-938.

Kahneman, D., & Tversky, A. (1979). Propect theory: an analysis of decision under risk. *Econometrica , 47* (2), 263-291.

Kay, J. (2009). *Wind down the market in five-legged dogs.* London: Financial Times.

Kemna, A., & Vorst, A. (1990). A pricing method for options based on average asset values. *Journal of Banking and Finance , 14* (1), 113-129.

Kleven, E. (2008). *Supervision and regulation of the structured products market in Norway.* Retrieved 6 1, 2009, from Kredittilsynet: http://www.kredittilsynet.no/en/System-pages/Secondary-menu-elements/Documents/Presentations-and-speeches/Supervision-and-regulation-of-the-structured-products-market-in-Norway/

Knutsen, T., & Jensen, A. (1999). *Aksjeindeksobligasjoner - konstruksjon og verdsettelse av slike produkter.* Norges Handelshøyskole: Siviløkonomutredning i særområdet finansiering og finansiell økonomi.

Koekebakker, S., & Zakamouline, V. (2006). *Forventet avkastning på aksjeindeksobligasjoner.* Retrieved March 25, 2009, from Høyskolen i Agder working paper: http://www1.vg.no/uploaded/document/2006/8/18/AIO.pdf

Koekebakker, S., & Zakamouline, V. (2007). *Realisert avkastning på garanterte spareprodukter.* Høyskolen i Agder: www1.vg.no+aio_rapport_historiske_tall_juni_2007.pdf.

Kredittilsynet. (2006). *FOR 2006-09-25 nr 1317: Forskrift om opplysningsplikt ved tilbud om kjøp av sammensatte produkter.* Retrieved March 30, 2009, from Lovdata: http://www.lovdata.no/cgi-wift/ldles?doc=/sf/sf/sf-20060925-1317.html

Kredittilsynet. (No. 15/2006). *Informasjon og retningslinjer ved salg av sammensatte produkter.* Retrieved May 10, 2009, from Kredittilsynet:

http://www.kredittilsynet.no/no/Artikkelarkiv/Rundskriv/2006/Informasjon-og-retningslinjer-ved-salg-av-sammensatte-produkter/

Kredittilsynet. (No. 4/2004). *Informasjon ved salg av sammensatte produkter - herunder aksjeindekserte obligasjoner og innskudd.* Retrieved March 15, 2009, from Kredittilsynet: http://www.kredittilsynet.no/no/Artikkelarkiv/Rundskriv/2005/Informasjon-ved-salg-av-sammensatte-produkter-herunder-aksjeindekserte-obligasjoner-og-innskudd/

Kredittilsynet. (No. 4/2008). *Structured products - changes in regulations on the duty of disclosure in relation to structured products offered for purchase.* Retrieved May 10, 2009, from Kredittilsynet: http://www.kredittilsynet.no/en/System-pages/Secondary-menu-elements/Documents/Press-releases/Kredittilsynet-tightens-up-on-structured-products/

Kredittilsynet. (2008). *Undersøkelse av sammensatte produkter.* Oslo: Kredittilsynet.

Krogh, H. C. (2002). *Analyzing protected equity notes by means of Monte Carlo simulation.* Norges Handelshøyskole: Master thesis in International Business.

Kvalnes, Ø. (2009). *Mot of tillit - etikk for finansielle rådgivere.* Retrieved June 17, 2009, from Autorisasjonsordningen for Finansielle Rådgivere: http://www.autorisasjonsordningen.no/wp-content/uploads/mot_og_tillit_lav.pdf

Laise, E. (2008). *Another 'Safe' Bet Leaves Many Burned.* Retrieved March 5, 2009, from The Wall Street Journal: http://online.wsj.com/article/SB122636312365215727.html

Lie, M., Lindset, S., & Lund, A.-C. (2005). Garantibonus III. et bankinnskudd med "aksjeavkastning". *Praktisk Økonomi og Finans , 22* (1), 101-109.

Lindset, S. (2008). *Finansfaglig vurdering for Forbrukerrådet av "AIOer" og "BMAer".* Retrieved February 5, 2009, from Forbrukerrådet: http://multimedia.dn.no/archive/00164/Finansfaglig_vurder_164287a.pdf

Loven, T., & Garås, J. E. (2008). *Warrants og garanterte spareprodukter: eksotiske opsjoner for småsparere eller eksotiske gebyrer for selgerne?* Norges Handelshøyskole: Master Thesis in Financial Economics.

McDonald, R. L. (2006). *Derivatives Markets* (2nd ed.). Boston: Pearson Education, Inc.

Merton, R. (1973). Theory of rational option pricing. *Bell Journal of Economics and Management Science , 4* (1), 141-183.

Mishkin, F. S. (2007). *The economics of money, banking and financial markets* (8th Edition ed.). Boston: Pearson Addison Wesley.

Norges Bank. (2009). *Statsobligasjoner.* Retrieved June 14, 2009, from Norges Bank: http://www.norges-bank.no/templates/article____55496.aspx

Organisation for Economic Co-operation and Development. (2005). *Improving financial literacy : analysis of issues and policies.* Paris: OECD.

Ørjasæter, E. (2009). *Bjørnen sov i Kredittilsynet.* Retrieved June 1, 2009, from e24.no: http://e24.no/kommentar/e24-kommentar/article3052470.ece

Ormseth, G. (2009). *Lånefinansierte spareprodukter: bankene garanterer deg tap.* Retrieved April 20, 2009, from Dine Penger: http://www.vg.no/dinepenger/artikkel.php?artid=552527

Ormseth, G. (2007). *Professor-Norge slakter bankene - for dem som tror på julenissen og Nigeria-brev*. Retrieved April 1, 2009, from VG Nett - Dine Penger: http://www1.vg.no/pub/vgart.php?artid=189911

Rubinstein, M. (1975). Securities market efficiency in an arrow-debreu economu. *American Economic Review , 65* (5), 812-824.

Samuelson, P. (1965). Prrof that properly anticipated prices fluctuate randomly. *Industrial Management Review , 6* (2), 41-49.

SEC. (2003). *Regulation C.* Retrieved February 28, 2009, from U.S. Securities and Exchange Commission Home Page: http://www.sec.gov/divisions/corpfin/forms/regc.htm#delivery

Solvær, S., Steinnes, V. J., & Stølen, F. H. (2006). Garanterte spareprodukter, en gullgruve for bankene! *Praktisk Økonomi og Finans , 23* (2), 79-84.

Solvær, S., Steinnes, V. J., & Stølen, F. H. (2005). *Strukturerte spareprodukter - verdsettelse og markedsføring.* Norges Handelshøyskole: Master Thesis in Financial Economics.

Sparre, M. (2008). *Lukrativt å lure folk*. Retrieved 2 13, 2009, from Dagens Næringsliv: http://www.dn.no/privatokonomi/article1295722.ece

Sparre, M. R. (2009a). *-Jeg ville ikke investert en krone*. Retrieved 1 26, 2009, from Dagens Næringsliv: http://www.dn.no/forsiden/naringsliv/article1592320.ece

Sparre, M. R. (2009b). *Oppgjør med naive nordmenn.* Retrieved May 11, 2009, from Dagens Næringsliv: http://www.abcnyheter.no/node/88593

Sparre, M. R. (2009c). *-Skal bli moro å kjøre dem i retten*. Retrieved 2 13, 2009, from Dagens Næringsliv: http://www.dn.no/privatokonomi/article1604089.ece

Sparre, M. R. (2009d). *-Vi ble belønnet for råsalg*. Retrieved 2 4, 2009, from Dagens Næringsliv: http://www.dn.no/privatokonomi/article1301405.ece

SSB. (2009b). *201 Sum. Balanse med spesifikasjoner*. Retrieved March 30, 2009, from Statistics Norway: http://www.ssb.no/emner/10/13/10/orbofbm/tab-201.html

SSB. (2009a). *43 Banker. Spesifikasjoner av innskudd på forskjellige innskuddstyper.* Retrieved March 30, 2009, from Statistics Norway: http://www.ssb.no/emner/10/13/10/orbofbm/tab-043.html

SSB. (2009c). *Banker. Garanterte spareprodukter, utlån til garanterte spareprodukter og utlånsandeler*. . Retrieved June 12, 2009, from Statistics Norway: http://www.ssb.no/emner/10/13/10/orbofbm/arkiv/ttab-2009-05-08-01.html

Staavi, T. (2006). *Bankene er avslørt!* Retrieved February 3, 2009, from Dine Penger: http://www.vg.no/dinepenger/artikkel.php?artid=137500

STOXX Limited. (2009). *Historical index values*. Retrieved May 5, 2009, from STOXX.com | Blue-chip indices : http://www.stoxx.com/indices/types/bluechip.html

Stranden, A. L. (2009). *-DnB har brutt loven.* Retrieved June 15, 2009, from Dine Penger: http://www.vg.no/dinepenger/artikkel.php?artid=554318

Sture, S. J. (2001). *Verdsettelse av DnB aksjeindeksobligasjon Global Titans 2001/2006.* Norges Handelshøyskole: Utredning i fordypningsområdet finansiering og finansiell økonomi.

Tørring, C. S. (2009). *Vil kaste rådgiverne ut av banken*. Retrieved 4 27, 2009, from Dine Penger: http://www.vg.no/dinepenger/artikkel.php?artid=542534

Tørrvold, C. (2009). *Fagpressens hederspris til Dine Pengers sjefredaktør.* Retrieved June 5, 2009, from Dine Penger: http://www.vg.no/dinepenger/artikkel.php?artid=544288

TSE Group, Inc. (2009). *Statistics*. Retrieved May 18, 2009, from Tokyo Stock Exchange: http://www.tse.or.jp/english/market/data/index.html

Tversky, A., & Kahneman, D. (1991). Loss aversion in riskless choice: a reference-dependent model. *The Quarterly Journal of Economics , 106* (4), 1039-1061.

Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science , 211* (4481), 453-458.

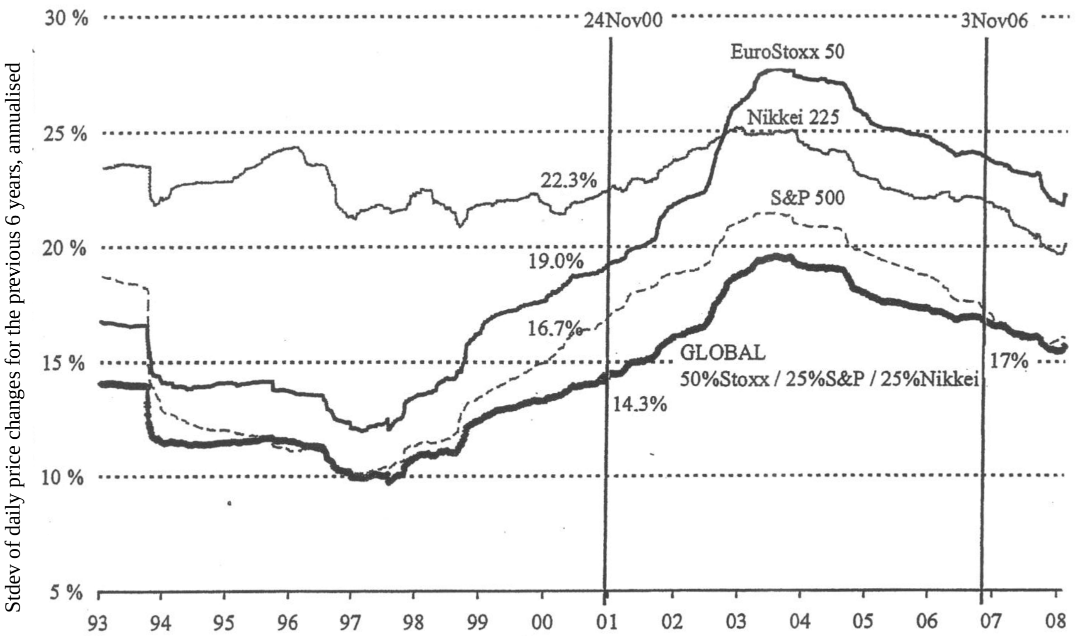
Vanvik, H. (2009, February 12). Hedgefond-salg til dement 88-åring. *Dagens Næringsliv* , 24-25.

Wangen, K. A. (2004). *Aksjeindeksobligasjoner - simulering og verdsetting.* Norges Handelshøyskole: Master thesis in Financial Economics.

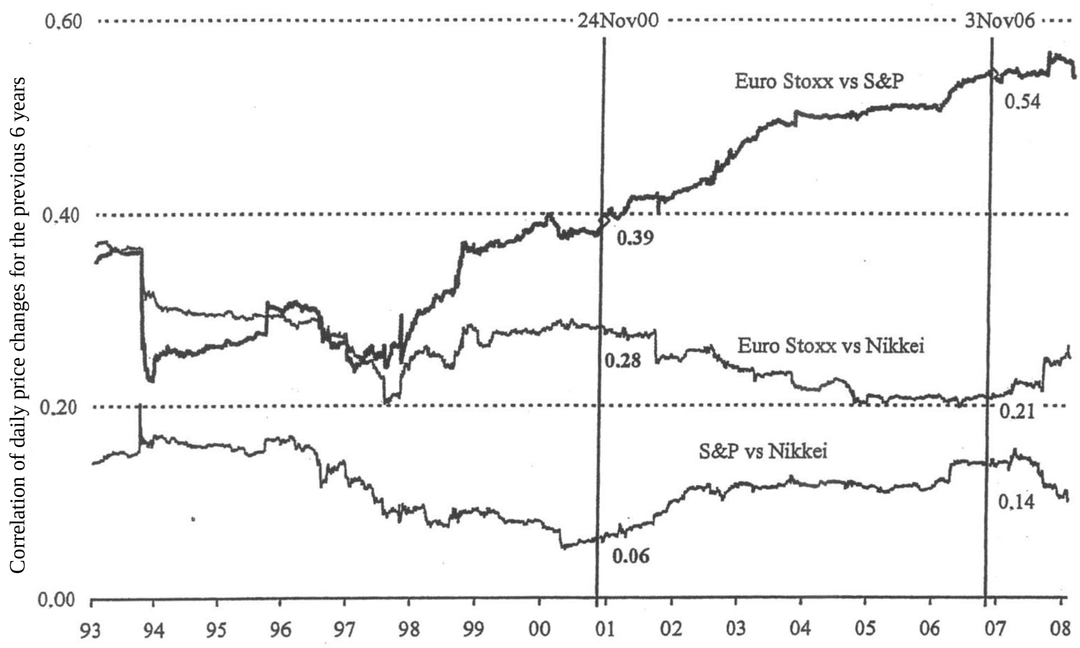
# 8. Appendix

## 8.1 6-year correlations and volatilities for the Global and Sektor portfolios from Johnsen (2008)

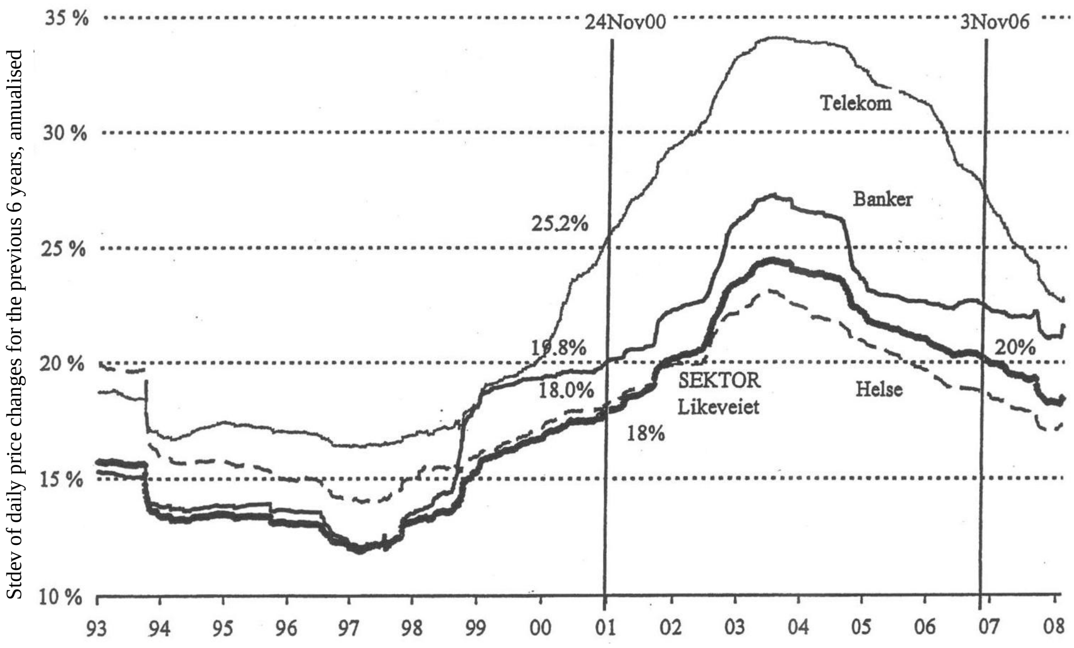
### 8.1.1 6-year historic volatility for Global sub-indices



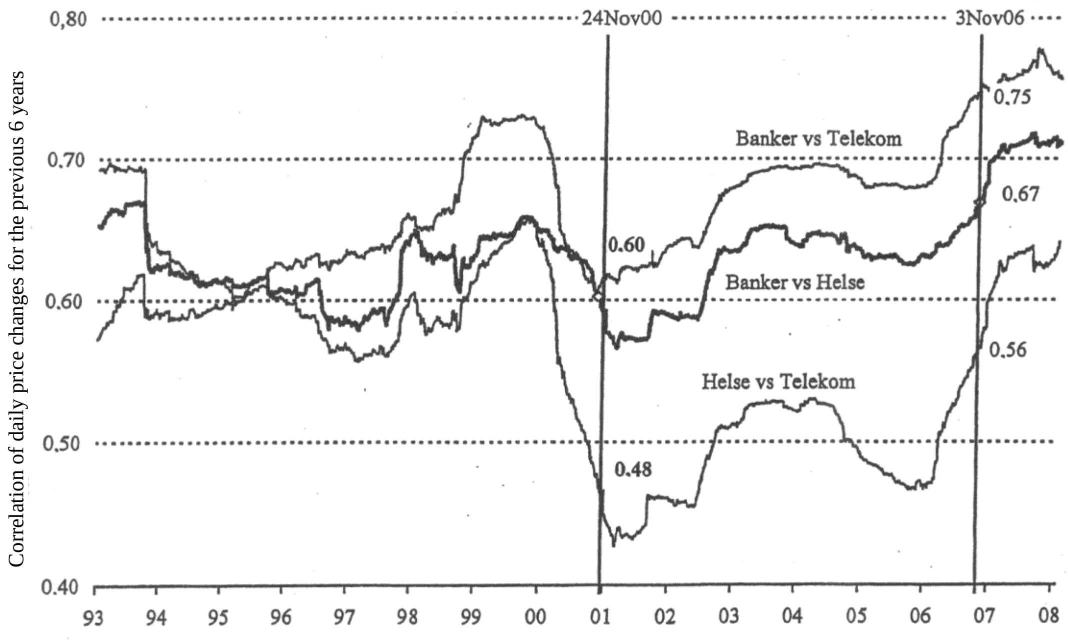

### 8.1.2 6-year historic correlation for Global sub-indices



## 8.1.3 6-year historic volatility for Sektor sub-indices




## 8.1.4 6-year historic correlation for Sektor sub-indices



# 8.2 Excel macros (Visual Basic for Applications)

## 8.2.1 Code for Cholesky decomposition

The Cholesky decomposition is commonly used in the MC method for simulating systems with multiple correlated variables: The matrix of inter-variable correlations is decomposed, to give the lower-triangular **L**. Applying this to a vector of uncorrelated simulated shocks, **u**, produces a shock vector **Lu** with the covariance properties of the system being modeled. The following code is from Bøe (2007)

```
Public Function Cholesky(mat As Range)
Dim a, L() As Double, S As Double
a = mat
N = mat.Rows.Count
M = mat.Columns.Count
If N <> M Then
   Cholesky = "?"
   Exit Function
End If

ReDim L(1 To N, 1 To N)
For j = 1 To N
   S = 0
   For K = 1 To j - 1
      S = S + L(j, K) ^ 2
   Next K
   L(j, j) = a(j, j) - S
   If L(j, j) <= 0 Then Exit For
   L(j, j) = Sqr(L(j, j))

   For i = j + 1 To N
      S = 0
      For K = 1 To j - 1
         S = S + L(i, K) * L(j, K)
      Next K
      L(i, j) = (a(i, j) - S) / L(j, j)
   Next i
Next j
Cholesky = L
End Function
```

### 8.2.2 Code for the simulation sub CalculateOption()

The following sub was written in VBA for the purpose of running the Monte Carlo simulation. The sub is based on lecture materials from FIE425 Derivatives and risk management which in the autumn semester 2007 was taught by Professor Svein Arne-Persson.

```
Sub CalculateOption()

  Columns("q:q").ClearContents
  Application.ScreenUpdating = False

i = 0
Dim time As Double
time = Now

iterations = Range("c19").Value

Do While i < (iterations + 1)

Range("q" & i + 1).Value = Range("c25").Value
i = i + 1
Ark1.Calculate

Loop
Range("C30").Value = Now - time


End Sub
```

## 8.3 Estimated volatility and correlations for sub indices

The following tables shows the percent by which volatility (correlation) for the individual indices would need to increase holding correlation (volatility) constant, in order to correspond with the expected portfolio volatility for DnB NOR and Johnsen respectively.

### 8.3.1 DnB NOR Markets: Global

| DnB NOR Markets | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Holding correlation constant<br>**Volatility** | | | | | Holding volatility constant<br>**Correlations** | | | | |
| + | EuroSTOXX50 | S&P500 | Nikkei225 | GLOBAL | + | EuroStoxx50 vs S&P 500 | EuroStoxx50 vs Nikkei225 | S&P 500 vs Nikkei225 | GLOBAL |
| - | 19.00% | 16.70% | 22.30% | 14.22% | - | 0.39 | 0.28 | 0.06 | 14.22% |
| 1% | 19.19% | 16.87% | 22.52% | 14.36% | 1% | 0.3939 | 0.2828 | 0.0606 | 14.24% |
| 2% | 19.38% | 17.03% | 22.75% | 14.50% | 2% | 0.3978 | 0.2856 | 0.0612 | 14.26% |
| 3% | 19.57% | 17.20% | 22.97% | 14.64% | 3% | 0.4017 | 0.2884 | 0.0618 | 14.28% |
| 4% | 19.76% | 17.37% | 23.19% | 14.79% | 4% | 0.4056 | 0.2912 | 0.0624 | 14.31% |
| 5% | 19.95% | 17.54% | 23.42% | 14.93% | 5% | 0.4095 | 0.2940 | 0.0630 | 14.33% |
| 6% | 20.14% | 17.70% | 23.64% | 15.07% | 6% | 0.4134 | 0.2968 | 0.0636 | 14.35% |
| 7% | 20.33% | 17.87% | 23.86% | 15.21% | 7% | 0.4173 | 0.2996 | 0.0642 | 14.37% |
| 8% | 20.52% | 18.04% | 24.08% | 15.36% | 8% | 0.4212 | 0.3024 | 0.0648 | 14.40% |
| 9% | 20.71% | 18.20% | 24.31% | 15.50% | 9% | 0.4251 | 0.3052 | 0.0654 | 14.42% |
| 10% | 20.90% | 18.37% | 24.53% | 15.64% | 10% | 0.4290 | 0.3080 | 0.0660 | 14.44% |
| 45% | 27.55% | 24.22% | 32.34% | 20.62% | 45% | 0.5655 | 0.4060 | 0.0870 | 15.19% |
| 46% | 27.74% | 24.38% | 32.56% | 20.76% | 46% | 0.5694 | 0.4088 | 0.0876 | 15.21% |
| 47% | 27.93% | 24.55% | 32.78% | 20.90% | 47% | 0.5733 | 0.4116 | 0.0882 | 15.23% |
| 48% | 28.12% | 24.72% | 33.00% | 21.04% | 48% | 0.5772 | 0.4144 | 0.0888 | 15.25% |
| 49% | 28.31% | 24.88% | 33.23% | 21.18% | 49% | 0.5811 | 0.4172 | 0.0894 | 15.27% |
| 50% | 28.50% | 25.05% | 33.45% | 21.33% | 50% | 0.5850 | 0.4200 | 0.0900 | 15.29% |
| 51% | 28.69% | 25.22% | 33.67% | 21.47% | 51% | 0.5889 | 0.4228 | 0.0906 | 15.31% |
| 52% | 28.88% | 25.38% | 33.90% | 21.61% | 52% | 0.5928 | 0.4256 | 0.0912 | 15.33% |
| 53% | 29.07% | 25.55% | 34.12% | 21.75% | 53% | 0.5967 | 0.4284 | 0.0918 | 15.35% |
| 54% | 29.26% | 25.72% | 34.34% | 21.90% | 54% | 0.6006 | 0.4312 | 0.0924 | 15.37% |
| 55% | 29.45% | 25.89% | 34.57% | 22.04% | 55% | 0.6045 | 0.4340 | 0.0930 | 15.40% |
| 56% | 29.64% | 26.05% | 34.79% | 22.18% | 56% | 0.6084 | 0.4368 | 0.0936 | 15.42% |
| 66.03% | 31.55% | 27.73% | 37.02% | 23.61% | 560% | 2.5730 | 1.8473 | 0.3958 | 23.60% |

### 8.3.2 DnB NOR Markets: Sektor

| DnB NOR Markets | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Holding correlation constant | | | | | Holding volatility constant | | | | |
| Volatility | | | | | Correlations | | | | |
| + | STOXX Healthcare | STOXX Telecom | STOXX Bank | SEKTOR | + | Healthcare vs Telecom | Healthcare vs Bank | Telecom vs Bank | GLOBAL |
| - | 18.00% | 25.20% | 19.80% | 17.68% | - | 0.48 | 0.60 | 0.60 | 17.68% |
| 1% | 18.18% | 25.45% | 20.00% | 17.86% | 1% | 0.4848 | 0.6060 | 0.6060 | 17.73% |
| 2% | 18.36% | 25.70% | 20.20% | 18.03% | 2% | 0.4896 | 0.6120 | 0.6120 | 17.77% |
| 3% | 18.54% | 25.96% | 20.39% | 18.21% | 3% | 0.4944 | 0.6180 | 0.6180 | 17.82% |
| 4% | 18.72% | 26.21% | 20.59% | 18.39% | 4% | 0.4992 | 0.6240 | 0.6240 | 17.86% |
| 5% | 18.90% | 26.46% | 20.79% | 18.56% | 5% | 0.5040 | 0.6300 | 0.6300 | 17.91% |
| 27% | 22.86% | 32.00% | 25.15% | 22.45% | 27% | 0.6096 | 0.7620 | 0.7620 | 18.88% |
| 28% | 23.04% | 32.26% | 25.34% | 22.63% | 28% | 0.6144 | 0.7680 | 0.7680 | 18.92% |
| 29% | 23.22% | 32.51% | 25.54% | 22.81% | 29% | 0.6192 | 0.7740 | 0.7740 | 18.96% |
| 30% | 23.40% | 32.76% | 25.74% | 22.98% | 30% | 0.6240 | 0.7800 | 0.7800 | 19.01% |
| 31% | 23.58% | 33.01% | 25.94% | 23.16% | 31% | 0.6288 | 0.7860 | 0.7860 | 19.05% |
| 32% | 23.76% | 33.26% | 26.14% | 23.34% | 32% | 0.6336 | 0.7920 | 0.7920 | 19.09% |
| 33% | 23.94% | 33.52% | 26.33% | 23.51% | 33% | 0.6384 | 0.7980 | 0.7980 | 19.14% |
| 34% | 24.12% | 33.77% | 26.53% | 23.69% | 34% | 0.6432 | 0.8040 | 0.8040 | 19.18% |
| 45% | 26.10% | 36.54% | 28.71% | 25.63% | 45% | 0.6960 | 0.8700 | 0.8700 | 19.64% |
| 46% | 26.28% | 36.79% | 28.91% | 25.81% | 46% | 0.7008 | 0.8760 | 0.8760 | 19.68% |
| 47% | 26.46% | 37.04% | 29.11% | 25.99% | 47% | 0.7056 | 0.8820 | 0.8820 | 19.72% |
| 48% | 26.64% | 37.30% | 29.30% | 26.17% | 48% | 0.7104 | 0.8880 | 0.8880 | 19.76% |
| 49% | 26.82% | 37.55% | 29.50% | 26.34% | 49% | 0.7152 | 0.8940 | 0.8940 | 19.80% |
| 50% | 27.00% | 37.80% | 29.70% | 26.52% | 50% | 0.7200 | 0.9000 | 0.9000 | 19.84% |
| 51% | 27.18% | 38.05% | 29.90% | 26.70% | 51% | 0.7248 | 0.9060 | 0.9060 | 19.88% |
| 52% | 27.36% | 38.30% | 30.10% | 26.87% | 52% | 0.7296 | 0.9120 | 0.9120 | 19.93% |
| 53% | 27.54% | 38.56% | 30.29% | 27.05% | 53% | 0.7344 | 0.9180 | 0.9180 | 19.97% |
| 54% | 27.72% | 38.81% | 30.49% | 27.23% | 54% | 0.7392 | 0.9240 | 0.9240 | 20.01% |
| 55% | 27.90% | 39.06% | 30.69% | 27.40% | 55% | 0.7440 | 0.9300 | 0.9300 | 20.05% |
| 78% | 32.04% | 44.86% | 35.24% | 31.47% | 78% | 0.8544 | 1.0680 | 1.0680 | 20.96% |
| 79% | 32.22% | 45.11% | 35.44% | 31.65% | 79% | 0.8592 | 1.0740 | 1.0740 | 21.00% |
| 62% | 29.12% | 40.77% | 32.03% | 28.60% | 311% | 1.9735 | 2.4669 | 2.4669 | 28.60% |

## 8.3.3 Johnsen: Global

| Johnsen | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Holding correlation constant | | | | | Holding volatility constant | | | | |
| Volatility | | | | | Correlations | | | | |
| + | EuroSTOXX50 | S&P500 | Nikkei225 | GLOBAL | + | EuroStoxx50 vs S&P 500 | EuroStoxx50 vs Nikkei225 | S&P 500 vs Nikkei225 | GLOBAL |
| - | 19.00% | 16.70% | 22.30% | 14.22% | - | 0.39 | 0.28 | 0.06 | 14.22% |
| 1% | 19.19% | 16.87% | 22.52% | 14.36% | 1% | 0.3939 | 0.2828 | 0.0606 | 14.24% |
| 2% | 19.38% | 17.03% | 22.75% | 14.50% | 2% | 0.3978 | 0.2856 | 0.0612 | 14.26% |
| 3% | 19.57% | 17.20% | 22.97% | 14.64% | 3% | 0.4017 | 0.2884 | 0.0618 | 14.28% |
| 11% | 21.09% | 18.54% | 24.75% | 15.78% | 11% | 0.4329 | 0.3108 | 0.0666 | 14.46% |
| 12% | 21.28% | 18.70% | 24.98% | 15.92% | 12% | 0.4368 | 0.3136 | 0.0672 | 14.48% |
| 13% | 21.47% | 18.87% | 25.20% | 16.07% | 13% | 0.4407 | 0.3164 | 0.0678 | 14.50% |
| 14% | 21.66% | 19.04% | 25.42% | 16.21% | 14% | 0.4446 | 0.3192 | 0.0684 | 14.53% |
| 15% | 21.85% | 19.21% | 25.65% | 16.35% | 15% | 0.4485 | 0.3220 | 0.0690 | 14.55% |
| 16% | 22.04% | 19.37% | 25.87% | 16.49% | 16% | 0.4524 | 0.3248 | 0.0696 | 14.57% |
| 17% | 22.23% | 19.54% | 26.09% | 16.64% | 17% | 0.4563 | 0.3276 | 0.0702 | 14.59% |
| 18% | 22.42% | 19.71% | 26.31% | 16.78% | 18% | 0.4602 | 0.3304 | 0.0708 | 14.61% |
| 19% | 22.61% | 19.87% | 26.54% | 16.92% | 19% | 0.4641 | 0.3332 | 0.0714 | 14.64% |
| 20% | 22.80% | 20.04% | 26.76% | 17.06% | 20% | 0.4680 | 0.3360 | 0.0720 | 14.66% |
| 21% | 22.99% | 20.21% | 26.98% | 17.20% | 21% | 0.4719 | 0.3388 | 0.0726 | 14.68% |
| 22% | 23.18% | 20.37% | 27.21% | 17.35% | 22% | 0.4758 | 0.3416 | 0.0732 | 14.70% |
| 23% | 23.37% | 20.54% | 27.43% | 17.49% | 23% | 0.4797 | 0.3444 | 0.0738 | 14.72% |
| 24% | 23.56% | 20.71% | 27.65% | 17.63% | 24% | 0.4836 | 0.3472 | 0.0744 | 14.74% |
| 36% | 25.84% | 22.71% | 30.33% | 19.34% | 36% | 0.5304 | 0.3808 | 0.0816 | 15.00% |
| 37% | 26.03% | 22.88% | 30.55% | 19.48% | 37% | 0.5343 | 0.3836 | 0.0822 | 15.02% |
| 38% | 26.22% | 23.05% | 30.77% | 19.62% | 38% | 0.5382 | 0.3864 | 0.0828 | 15.04% |
| 39% | 26.41% | 23.21% | 31.00% | 19.76% | 39% | 0.5421 | 0.3892 | 0.0834 | 15.06% |
| 40% | 26.60% | 23.38% | 31.22% | 19.91% | 40% | 0.5460 | 0.3920 | 0.0840 | 15.08% |
| 41% | 26.79% | 23.55% | 31.44% | 20.05% | 41% | 0.5499 | 0.3948 | 0.0846 | 15.10% |
| 42% | 26.98% | 23.71% | 31.67% | 20.19% | 42% | 0.5538 | 0.3976 | 0.0852 | 15.13% |
| 43% | 27.17% | 23.88% | 31.89% | 20.33% | 43% | 0.5577 | 0.4004 | 0.0858 | 15.15% |
| 71% | 32.49% | 28.56% | 38.13% | 24.31% | 71% | 0.6669 | 0.4788 | 0.1026 | 15.72% |
| 72% | 32.68% | 28.72% | 38.36% | 24.45% | 72% | 0.6708 | 0.4816 | 0.1032 | 15.74% |
| 26.6% | 24.05% | 21.14% | 28.23% | 18.00% | 192% | 1.1397 | 0.8182 | 0.1753 | 18.00% |

### 8.3.4 Johnsen: Sektor

| Johnsen | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Holding correlation constant | | | | | Holding volatility constant | | | | |
| Volatility | | | | | Correlations | | | | |
| + | STOXX Healthcare | STOXX Telecom | STOXX Bank | SEKTOR | + | Healthcare vs Telecom | Healthcare vs Bank | Telecom vs Bank | GLOBAL |
| - | 18.00% | 25.20% | 19.80% | 17.68% | - | 0.48 | 0.60 | 0.60 | 17.68% |
| 1% | 18.18% | 25.45% | 20.00% | 17.86% | 1% | 0.4848 | 0.6060 | 0.6060 | 17.73% |
| 2% | 18.36% | 25.70% | 20.20% | 18.03% | 2% | 0.4896 | 0.6120 | 0.6120 | 17.77% |
| 3% | 18.54% | 25.96% | 20.39% | 18.21% | 3% | 0.4944 | 0.6180 | 0.6180 | 17.82% |
| 15% | 20.70% | 28.98% | 22.77% | 20.33% | 15% | 0.5520 | 0.6900 | 0.6900 | 18.36% |
| 16% | 20.88% | 29.23% | 22.97% | 20.51% | 16% | 0.5568 | 0.6960 | 0.6960 | 18.40% |
| 17% | 21.06% | 29.48% | 23.17% | 20.68% | 17% | 0.5616 | 0.7020 | 0.7020 | 18.44% |
| 18% | 21.24% | 29.74% | 23.36% | 20.86% | 18% | 0.5664 | 0.7080 | 0.7080 | 18.49% |
| 19% | 21.42% | 29.99% | 23.56% | 21.04% | 19% | 0.5712 | 0.7140 | 0.7140 | 18.53% |
| 20% | 21.60% | 30.24% | 23.76% | 21.21% | 20% | 0.5760 | 0.7200 | 0.7200 | 18.58% |
| 21% | 21.78% | 30.49% | 23.96% | 21.39% | 21% | 0.5808 | 0.7260 | 0.7260 | 18.62% |
| 22% | 21.96% | 30.74% | 24.16% | 21.57% | 22% | 0.5856 | 0.7320 | 0.7320 | 18.66% |
| 23% | 22.14% | 31.00% | 24.35% | 21.75% | 23% | 0.5904 | 0.7380 | 0.7380 | 18.71% |
| 24% | 22.32% | 31.25% | 24.55% | 21.92% | 24% | 0.5952 | 0.7440 | 0.7440 | 18.75% |
| 63% | 29.34% | 41.08% | 32.27% | 28.82% | 63% | 0.7824 | 0.9780 | 0.9780 | 20.37% |
| 64% | 29.52% | 41.33% | 32.47% | 28.99% | 64% | 0.7872 | 0.9840 | 0.9840 | 20.41% |
| 65% | 29.70% | 41.58% | 32.67% | 29.17% | 65% | 0.7920 | 0.9900 | 0.9900 | 20.45% |
| 66% | 29.88% | 41.83% | 32.87% | 29.35% | 66% | 0.7968 | 0.9960 | 0.9960 | 20.49% |
| 67% | 30.06% | 42.08% | 33.07% | 29.52% | 67% | 0.8016 | 1.0020 | 1.0020 | 20.53% |
| 68% | 30.24% | 42.34% | 33.26% | 29.70% | 68% | 0.8064 | 1.0080 | 1.0080 | 20.57% |
| 69% | 30.42% | 42.59% | 33.46% | 29.88% | 69% | 0.8112 | 1.0140 | 1.0140 | 20.61% |
| 70% | 30.60% | 42.84% | 33.66% | 30.05% | 70% | 0.8160 | 1.0200 | 1.0200 | 20.65% |
| 71% | 30.78% | 43.09% | 33.86% | 30.23% | 71% | 0.8208 | 1.0260 | 1.0260 | 20.69% |
| 72% | 30.96% | 43.34% | 34.06% | 30.41% | 72% | 0.8256 | 1.0320 | 1.0320 | 20.72% |
| 24.4% | 22.40% | 31.36% | 24.64% | 22.00% | 106% | 0.9866 | 1.2333 | 1.2333 | 22.00% |

# 8.4 Simulation results

## 8.4.1 Simulation results DnB NOR: Global, arithmetic risk premiums

| Number of runs | Return on option | Return on indexed bond | TR Equity | P.a. Return equity | TR Debt | P.a. Return debt | Standard deviation of total simulation |
|---|---|---|---|---|---|---|---|
| 10 | 87.9632% | 92.3614% | 84.0779% | 10.7049% | 21.7787% | 3.3384% | 38.7405% |
| 100 | 71.0346% | 74.5864% | 67.0683% | 8.9304% | 4.0037% | 0.6564% | 7.8698% |
| 1,000 | 72.0134% | 75.6140% | 68.0517% | 9.0370% | 5.0314% | 0.8215% | 3.1381% |
| 10,000 | 67.0514% | 70.4040% | 63.0660% | 8.4910% | -0.1787% | -0.0298% | 0.9106% |
| 100,000 | 67.2298% | 70.5913% | 63.2453% | 8.5109% | 0.0087% | 0.0014% | 0.2859% |
| 1,000,000 | 67.8115% | 71.2021% | 63.8298% | 8.5756% | 0.6195% | 0.1030% | 0.0914% |

| 95% confidence interval for trial | Equity: μ - (1.96*σ)/√m | Equity: μ + (1.96*σ)/√m | Debt: μ - (1.96*σ)/√m | Debt: μ + (1.96*σ)/√m |
|---|---|---|---|---|
| 10 | -13.3067% | 34.7165% | -20.6732% | 27.3501% |
| 100 | 7.3879% | 10.4729% | -0.8861% | 2.1989% |
| 1,000 | 8.8425% | 9.2315% | 0.6270% | 1.0160% |
| 10,000 | 8.4732% | 8.5089% | -0.0477% | -0.0120% |
| 100,000 | 8.5091% | 8.5127% | -0.0003% | 0.0032% |
| 1,000,000 | 8.5754% | 8.5758% | 0.1028% | 0.1032% |

## 8.4.2 Simulation results DnB NOR: Global, geometric risk premiums

| Number of runs | Return on option | Return on indexed bond | TR Equity | P.a. Return equity | TR Debt | P.a. Return debt | Standard deviation of total simulation |
|---|---|---|---|---|---|---|---|
| 10 | 53.2747% | 55.9384% | 49.2233% | 6.8988% | -14.6443% | -2.6045% | 26.4966% |
| 100 | 43.9962% | 46.1960% | 39.9005% | 5.7556% | -24.3867% | -4.5521% | 6.1275% |
| 1,000 | 53.0747% | 55.7285% | 49.0225% | 6.8748% | -14.8542% | -2.6445% | 2.4179% |
| 10,000 | 55.3002% | 58.0652% | 51.2586% | 7.1404% | -12.5174% | -2.2042% | 0.7910% |
| 100,000 | 55.7918% | 58.5814% | 51.7526% | 7.1987% | -12.0012% | -2.1082% | 0.2521% |

| 95% confidence interval for trial | Equity: μ - (1.96*σ)/√m | Equity: μ + (1.96*σ)/√m | Debt: μ - (1.96*σ)/√m | Debt: μ + (1.96*σ)/√m |
|---|---|---|---|---|
| 10 | -9.5240% | 23.3216% | -19.0273% | 13.8182% |
| 100 | 4.5546% | 6.9566% | -5.7531% | -3.3511% |
| 1,000 | 6.7249% | 7.0247% | -2.7943% | -2.4946% |
| 10,000 | 7.1249% | 7.1559% | -2.2197% | -2.1887% |
| 100,000 | 7.1971% | 7.2002% | -2.1098% | -2.1067% |

## 8.4.3 Simulation results DnB NOR: Sektor, arithmetic risk premiums

| Number of runs | Return on option | Return on indexed bond | TR Equity | P.a. Return equity | TR Debt | P.a. Return debt | Standard deviation of total simulation |
|---|---|---|---|---|---|---|---|
| 10 | 71.3141% | 71.3141% | 63.9369% | 8.5874% | 0.7314% | 0.1215% | 21.2429% |
| 100 | 67.8770% | 67.8770% | 60.6478% | 8.2212% | -2.7057% | -0.4561% | 9.23% |
| 1,000 | 80.9670% | 80.9670% | 73.1742% | 9.5840% | 10.3844% | 1.6603% | 3.29% |
| 10,000 | 80.4403% | 80.4403% | 72.6702% | 9.5308% | 9.8577% | 1.5793% | 1.15% |
| 100,000 | 80.3431% | 80.3431% | 72.5771% | 9.5209% | 9.7604% | 1.5643% | 0.37% |
| 1,000,000 | 80.3695% | 80.3695% | 72.6024% | 9.5236% | 9.7868% | 1.5683% | 0.12% |

| 95% confidence interval for trial | Equity: μ - (1.96*σ)/√m | Equity: μ + (1.96*σ)/√m | Debt: μ - (1.96*σ)/√m | Debt: μ + (1.96*σ)/√m |
|---|---|---|---|---|
| 10 | -4.5791% | 21.7539% | -13.0450% | 13.2880% |
| 100 | 6.4117% | 10.0308% | -2.2657% | 1.3534% |
| 1,000 | 9.3799% | 9.7881% | 1.4561% | 1.8644% |
| 10,000 | 9.5082% | 9.5534% | 1.5566% | 1.6019% |
| 100,000 | 9.5187% | 9.5232% | 1.5620% | 1.5666% |
| 1,000,000 | 9.5234% | 9.5238% | 1.5681% | 1.5686% |

### 8.4.4 Simulation results DnB NOR: Sektor, geometric risk premiums

| Number of runs | Return on option | Return on indexed bond | TR Equity | P.a. Return equity | TR Debt | P.a. Return debt | Standard deviation of total simulation |
|---|---|---|---|---|---|---|---|
| 10 | 49.5373% | 49.5373% | 43.0979% | 6.1546% | -21.0453% | -3.8617% | 23.7498% |
| 100 | 42.6805% | 42.6805% | 36.5364% | 5.3274% | -27.9022% | -5.3065% | 7.15% |
| 1,000 | 57.8602% | 57.8602% | 51.0624% | 7.1172% | -12.7224% | -2.2424% | 2.92% |
| 10,000 | 53.8442% | 53.8442% | 47.2193% | 6.6582% | -16.7385% | -3.0069% | 0.88% |
| 100,000 | 54.9173% | 54.9173% | 48.2462% | 6.7818% | -15.6654% | -2.7997% | 0.29% |

| 95% confidence interval for trial | Equity: μ - (1.96*σ)/√m | Equity: μ + (1.96*σ)/√m | Debt: μ - (1.96*σ)/√m | Debt: μ + (1.96*σ)/√m |
|---|---|---|---|---|
| 10 | -8.5657% | 20.8749% | -18.5820% | 10.8585% |
| 100 | 3.9266% | 6.7282% | -6.7072% | -3.9057% |
| 1,000 | 6.9364% | 7.2981% | -2.4232% | -2.0616% |
| 10,000 | 6.6409% | 6.6754% | -3.0242% | -2.9897% |
| 100,000 | 6.7800% | 6.7836% | -2.8015% | -2.7979% |

### 8.4.5 Simulation results Johnsen: Global, arithmetic risk premiums

| Number of runs | Return on option | Return on indexed bond | TR Equity | P.a. Return equity | TR Debt | P.a. Return debt | Standard deviation of total simulation |
|---|---|---|---|---|---|---|---|
| 10 | 52.3208% | 54.9368% | 48.2649% | 6.7841% | -15.6458% | -2.7959% | 21.8008% |
| 100 | 42.5866% | 44.7159% | 38.4842% | 5.5764% | -25.8667% | -4.8660% | 5.1897% |
| 1,000 | 52.1394% | 54.7464% | 48.0827% | 6.7622% | -15.8363% | -2.8325% | 2.0226% |
| 10,000 | 51.5648% | 54.1431% | 47.5054% | 6.6927% | -16.4396% | -2.9490% | 0.5976% |
| 100,000 | 51.9542% | 54.5519% | 47.8966% | 6.7398% | -16.0307% | -2.8700% | 0.1912% |
| 1,000,000 | 51.7816% | 54.3707% | 47.7231% | 6.7189% | -16.2120% | -2.9050% | 0.0600% |

| 95% confidence interval for trial | Equity: μ - (1.96*σ)/√m | Equity: μ + (1.96*σ)/√m | Debt: μ - (1.96*σ)/√m | Debt: μ + (1.96*σ)/√m |
|---|---|---|---|---|
| 10 | -6.7282% | 20.2963% | -16.3082% | 10.7164% |
| 100 | 4.5592% | 6.5935% | -5.8832% | -3.8489% |
| 1,000 | 6.6368% | 6.8875% | -2.9579% | -2.7072% |
| 10,000 | 6.6810% | 6.7044% | -2.9607% | -2.9373% |
| 100,000 | 6.7386% | 6.7410% | -2.8712% | -2.8688% |
| 1,000,000 | 6.7188% | 6.7190% | -2.9051% | -2.9049% |

### 8.4.6 Simulation results Johnsen: Global, geometric risk premiums

| Number of runs | Return on option | Return on indexed bond | TR Equity | P.a. Return equity | TR Debt | P.a. Return debt | Standard deviation of total simulation |
|---|---|---|---|---|---|---|---|
| 10 | 24.4967% | 25.7215% | 20.3077% | 3.1293% | -44.8611% | -9.4456% | 9.6864% |
| 100 | 37.0346% | 38.8863% | 32.9056% | 4.8553% | -31.6964% | -6.1558% | 5.25% |
| 1,000 | 47.6260% | 50.0073% | 43.5476% | 6.2101% | -20.5754% | -3.7666% | 1.7690% |
| 10,000 | 45.6537% | 47.9364% | 41.5659% | 5.9643% | -22.6463% | -4.1894% | 0.5607% |
| 100,000 | 46.2152% | 48.5259% | 42.1301% | 6.0346% | -22.0567% | -4.0681% | 0.1773% |

| 95% confidence interval for trial | Equity: μ - (1.96*σ)/√m | Equity: μ + (1.96*σ)/√m | Debt: μ - (1.96*σ)/√m | Debt: μ + (1.96*σ)/√m |
|---|---|---|---|---|
| 10 | -2.8743% | 9.1330% | -15.4493% | -3.4419% |
| 100 | 3.8273% | 5.8834% | -7.1839% | -5.1278% |
| 1,000 | 6.1005% | 6.3198% | -3.8762% | -3.6569% |
| 10,000 | 5.9534% | 5.9753% | -4.2004% | -4.1784% |
| 100,000 | 6.0335% | 6.0357% | -4.0692% | -4.0670% |

## 8.4.7 Simulation results Johnsen: Sektor, arithmetic risk premiums

| Number of runs | Return on option | Return on indexed bond | TR Equity | P.a. Return equity | TR Debt | P.a. Return debt | Standard deviation of total simulation |
|---|---|---|---|---|---|---|---|
| 10 | 55.9628% | 55.9628% | 49.2467% | 6.9016% | -14.6199% | -2.5999% | 19.5991% |
| 100 | 51.8884% | 51.8884% | 45.3478% | 6.4310% | -18.6942% | -3.3904% | 6.6251% |
| 1,000 | 63.2511% | 63.2511% | 56.2211% | 7.7184% | -7.3316% | -1.2610% | 2.4027% |
| 10,000 | 60.1034% | 60.1034% | 53.2090% | 7.3695% | -10.4792% | -1.8281% | 0.7505% |
| 100,000 | 59.7128% | 59.7128% | 52.8352% | 7.3257% | -10.8699% | -1.8996% | 0.23% |
| 1,000,000 | 59.7169% | 59.7169% | 52.8392% | 7.3262% | -10.8657% | -1.8988% | 0.07% |

| 95% confidence interval for trial | Equity: μ - (1.96*σ)/√m | Equity: μ + (1.96*σ)/√m | Debt: μ - (1.96*σ)/√m | Debt: μ + (1.96*σ)/√m |
|---|---|---|---|---|
| 10 | -5.2461% | 19.0492% | -14.7476% | 9.5478% |
| 100 | 5.1325% | 7.7295% | -4.6889% | -2.0919% |
| 1,000 | 7.5695% | 7.8673% | -1.4099% | -1.1121% |
| 10,000 | 7.3547% | 7.3842% | -1.8428% | -1.8134% |
| 100,000 | 7.3243% | 7.3272% | -1.9011% | -1.8982% |
| 1,000,000 | 7.3261% | 7.3264% | -1.8990% | -1.8987% |

## 8.4.8 Simulation results Johnsen: Sektor, geometric risk premiums

| Number of runs | Return on option | Return on indexed bond | TR Equity | P.a. Return equity | TR Debt | P.a. Return debt | Standard deviation of total simulation |
|---|---|---|---|---|---|---|---|
| 10 | 30.9995% | 32.5495% | 26.8416% | 4.0424% | -38.0332% | -7.6664% | 9.6995% |
| 100 | 43.6900% | 45.8745% | 39.5928% | 5.7168% | -24.7082% | -4.6199% | 6.2655% |
| 1,000 | 40.6273% | 42.6587% | 36.5155% | 5.3247% | -27.9240% | -5.3112% | 1.7739% |
| 10,000 | 46.2434% | 48.5555% | 42.1584% | 6.0381% | -22.0271% | -4.0620% | 0.6447% |
| 100,000 | 45.1015% | 47.3566% | 41.0111% | 5.8950% | -23.2260% | -4.3095% | 0.20% |

| 95% confidence interval for trial | Equity: μ - (1.96*σ)/√m | Equity: μ + (1.96*σ)/√m | Debt: μ - (1.96*σ)/√m | Debt: μ + (1.96*σ)/√m |
|---|---|---|---|---|
| 10 | -1.9694% | 10.0542% | -13.6782% | -1.6546% |
| 100 | 4.4887% | 6.9448% | -5.8479% | -3.3918% |
| 1,000 | 5.2148% | 5.4347% | -5.4212% | -5.2013% |
| 10,000 | 6.0255% | 6.0508% | -4.0747% | -4.0494% |
| 100,000 | 5.8938% | 5.8963% | -4.3107% | -4.3082% |